The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

VOL. VIII. PITTSBURGH, PA., OCTOBER, 1920. No. 10

Electric Reversing Mill Considered from the Standpoint of Tonnage

Discussion of the Influence of the Control on the Rolling Time, Particularly to the Effect of Limiting the Maximum Power Delivered to the Direct Current Motor Driving the Rolls.

By K. A. PAULY.

OBVIOUSLY the principal factor which affects the hourly capacity of a mill is the time required to roll an ingot without exceeding the capacity of the drive to repeat this cycle indefinitely, and this paper is devoted largely to a discussion of the influence of the control on the rolling time, particularly to the effect of limiting the maximum power delivered to the direct current motor driving the rolls. As we are concerned only with the reversing mill proper, it is assumed that no unnecessary delays occur in the manipulation of the steel on the live roll tables, in the transfer of the ingots from the soaking pits or in the removal of the finished steel from the mill. If any improvement in these details is possible, no time should be lost in taking the necessary steps, whatever the type of drive used for the main rolls. We are, therefore, assuming that the mill is properly tuned up and that the intervals between passes are the same for all mills, referring briefly later to some of the characteristics of the different types of drives which tend to affect this interval.

Obviously the time required to roll an ingot, assuming the interval between passes the same, is increased directly by an increase in the time the steel is under the rolls. This in turn is affected by the speed at which the steel enters the rolls, the time required to accelerate to the maximum speed after the steel has entered, the maximum speed attainable and the time the rolls run at this speed during the pass and the time to retard the mill to a proper delivery speed at the end of the pass. The entering speed is limited largely by the section of the steel, the design of the rolls, the draft, etc., and is dependent of the drive. The delivery speed should be as high as is permissible without increasing the interval between passes, and as the time for retardation is extremely short with any drive it may be assumed without appreciable error to be the same for all. This leaves only the time required to accelerate after the steel enters and the maximum speed and the time of rolling at the maximum speed, which are subject to variations due to the speed-torque characteristic of the drive.

Right here I wish to caution against a very common mistake made by engineers when discussing reversing mill problems. We frequently hear the expression "the time of reversal" used. Do not confound this with the time required to accelerate, and if you use either the word "reversal" or the expression "acceleration and retardation," qualify your statement by the limiting speeds between which the reversal or acceleration and retardation takes place, e.g. from 90 rpm forward to 90 rpm reversed. By simply rocking a machine, it may be made to reverse many times a minute and yet be extremely slow in getting up to speed with steel in the rolls.

The reversing mill was first driven electrically abroad, where the requirements of these mills are very different from those in America. In general the rolls are larger in diameter, their speeds are higher and the tonnages very much smaller than is our practice. Naturally, therefore, we find the motors, generators and controls designed to meet these conditions rather than on the basis of producing the maximum tonnage from the mills which they drive. A complete description of one of the early German electrically driven reversing mills is given in "Stahl und Eisen" for January 23, 1907, from which the following short description of the system of control is taken:

"The main rolls are driven by three direct current motors direct connected to the mill and connected electrically in series and supplied from an Ilgner Ward Leonard flywheel set having two generators designed for 500 volts each, connected in series, making a total of 1,000 volts applied to the mill motors. The excitation for the motors and generators is obtained from a small exciter motor generator, consisting of two direct current generators driven by an induction motor. One of these generators serves to excite the shunt windings of the generators and main roll motors. The other generator of the exciter set supplies special compound windings provided for strengthening the fields of the roll motors as their loads increase, thereby causing a reduction in their speed and thus relieving the generators of the overloads which would other-

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Abstract of paper read at the convention of the Association of Iron and Steel Electrical Engineers, New York City, September 20-24, 1920.

wise be occasioned."

In America conditions are very different. Tonnage is usually the all important consideration and a fraction of a second per pass lost because of insufficient capacity in the drive, because of the roll motors due to special windings described above, or because the motors are prevented by any means from taking the peak loads required to properly accelerate with the piece in the rolls, will cost the operator, through the loss in production which follows, many times the few dollars he will save in the first cost of the equipment.

That reversing mill requirements are severe must be recognized and the machines used to drive them together with their controls designed to meet this condition with sufficient momentary peak load capacity to take care of the combined acceleration and rolling load of each pass, and with sufficient continuous capacity to roll constantly at the rate necessary to produce the required tonnage. I wish to take this opportunity to again emphasize the importance of preparing standard specifications covering reversing mill main roll drives, thus relieving the confusion which now exists because of the different methods of rating of these equipments now in use. That the need for this is fully appreciated by both the manufacturers and the operators is evidenced by the discussion which followed the reading of the paper "Standardization of Ratings of Large Rolling Mill Motors," presented by the writer at the Twelfth Annual Convention of the Association of Iron and Steel Electrical Engineers, held at Baltimore in September, 1918.

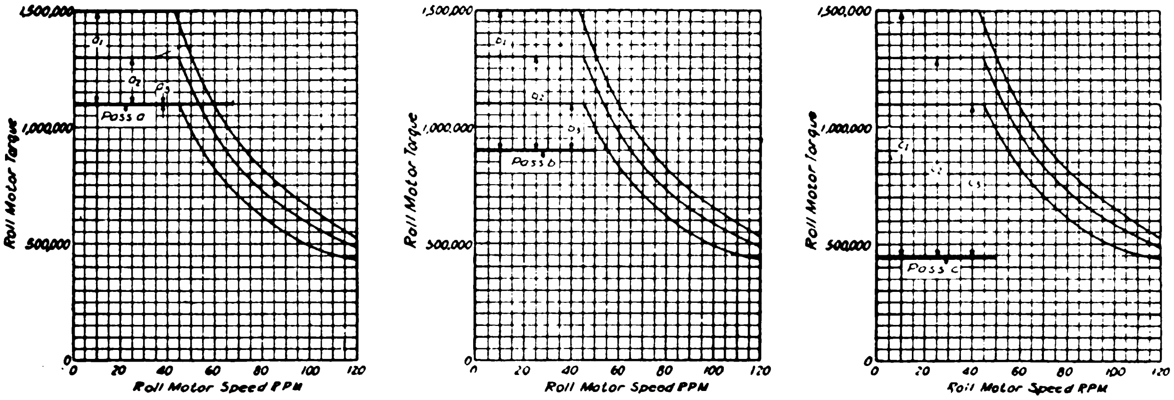

Fig. 1.

There is, of course, a limit to the capacity of any drive, and the characteristics of electrical equipment are such that unless some automatic means is provided for limiting the power of the roll motors a careless operator can abuse the electrical equipment. Current limit controls have been developed for this purpose, their function being to limit the current taken, and, therefore, the maximum power developed by the roll motors to a value which they and their generator can safely carry at frequent intervals. The current limit setting for the main roll motors, therefore, is a real indication of the relative peak load capacities for rolling steel of two equipments designed for the same voltage. The reader is cautioned not to confuse this limitation of the current taken by the roll motors with control of the induction motor driving the flywheel motor generator through the slip regulator. As time is required for the current limiting device to function, the current tends to rise above the value corresponding to the relay setting, but the peak in excess of the setting is of such short duration that it produces little effect on the acceleration of the roll motor. The effect of the setting of the current limit relay on the tonnage produced in the mill, and the importance of setting it for as high a current as is possible can be very well understood by a brief study of the effect of different current limit settings upon the time to make the pass.

For the purpose of comparison, we have assumed the mill to be driven by a motor with the current limit set for three different values—9,500 amperes, 8,500 amperes and 7,000 amperes, the potential of the generators supplying the motors being 1,200 volts when delivering the currents for which the current limit relays are adjusted and with the motor generators running at the minimum speed occurring during the normal rolling cycle. Such a generator or generators will develop 1,450 volts to 1,500 volts when running at full speed and carrying no load, and care must be taken in computing the horsepowers corresponding to any specified current limit settings that only the voltage delivered by the generators when delivering these currents is used and not the running light voltage, as is frequently done.

Now if our mill is to meet its tonnage requirements, it must be able to accelerate rapidly after the steel has entered, but we have only the motor torque available for acceleration after the steel has entered in excess of that required to roll and this decreases at a much greater rate than the reduction in current limit setting. This is clearly seen from a chart, Fig. 1, from which it will be seen that although the 8,500 ampere setting is only 13½ per cent less than the 9,500 ampere setting, the torque with the 8,500 ampere setting available for accelerating the mill after the steel has entered is for pass "a" only one-half of that with the 9,500 ampere setting, and for pass "b" is only two-thirds of that for the 9,500 ampere setting. This difference becomes still more marked as the current limit is further reduced until we reach the 7,000 ampere setting for which there is no torque available for acceleration after the pass "a" has entered, although the 7,000 ampere setting is only approximately 27 per cent below the 9,500 ampere setting. Also with the 7,000 ampere setting we have only one-third of the torque available for acceleration after pass "b" enters, that is available for the 9,500 ampere setting. At this setting the pass "a" cannot be rolled faster than the entering speed, and the speed during pass "b" can increase only slightly above the entering speed. As the current limit is reduced below 7,000 amperes it becomes necessary to increase the number of passes and to rearrange the rolling cycle, reducing the drafts of some of the passes and rolling others at the speeds at which the steel enters, the effect of which on the tonnage output of the mill is obvious.

On the other hand it is the peak load as determined by the current limit setting and not the magnitude of the torque available for acceleration a_1, a_2 a_3, b_1, etc., which affects the first cost of the equipment driving the mill and any saving in first cost conditioned upon a limitation of the current below the value required to roll with a reasonable margin available for acceleration after the steel enters is false economy. Furthermore, the first cost is affected by the continuous as well as the momentary peak load capacity. Therefore, the percentage increase in first cost will often be less than the percentage increase in the current limit setting which this increase in first cost buys. The current limit setting is, therefore, a matter which should be given very careful consideration in comparing equipments of this type.

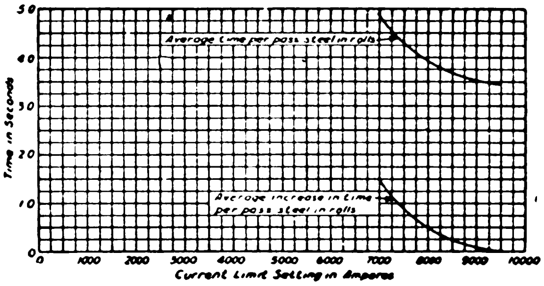

Fig. 2.

The effect of the current limit setting on the length of time to roll can be determined mathematically by the use of the following formula, by subdividing the roll motor torque curve into two parts; the portion corresponding to full motor field and that corresponding to weakened motor field.

The time "t" required to accelerate from a speed S_0 to S_1 and the distance traveled "d" by the steel during this time can be determined by the following formula:

When S_0 and S_1 fall within the full motor field portion of the speed torque curve,

$$t = \frac{.195\ WR^2\ (S_1 - S_0)}{T_r}$$

$$D = \frac{S_1 + S_0}{2}\ Lt$$

Where

WR = Weight in pounds times radius of gyration in feet squared of revolving parts of mill and drive.

Tr = Motor torque minus load torque; a^1, a^2, etc., Fig. 1.

L = Distance traveled in inches for one revolution of rolls.

When S_0 and S_1 fall within the weakened motor field portion of the speed torque curve:

$$t = \frac{K}{A_2}\left(A\ (S_1 - S_0)\ +\ HP_1\ \log_e \frac{HP_1 + AS_0}{HP_1 + AS_1} \right)$$

$$D = \frac{K}{A_1^2}\left(A^2 \frac{S^2_1\ -\ S^2_0}{2} - HP_1 A (S_1 - S_0) - HP^2_1 \log_e \frac{HP_1\ +\ AS_0}{HP_1\ +\ AS_1} \right)$$

Where

$K = .00223\ WR^2$

$A = \frac{T_1}{87.5}$

HP_1 = Maximum horsepower of motor as determined by the current limit setting.

T_1 = Torque required to roll.

The effect of lowering the current limit on the time required to roll is shown by the curves in Fig. No. 2, which are based on rolling the 8" x 8" bloom, from the 22" 24" ingot, referred to above. This curve has been extended back only to approximately 7,000 amperes as it becomes necessary to rearrange the passes, increasing the number and reducing the drafts, as the curent limit is reduced and the time for rolling further increased with corresponding reductions in tonnage output. The curve shows that lowering the current limit from 9,500 amperes to approximately 7,000 amperes increases the average time the steel is in the rolls by approximately 1½ seconds per pass, which for a 15 pass cycle means a loss of 22½ seconds per ingot, an amount which will seriously reduce the output of any mill designed for large or moderately large tonnage.

It is recognized that the rate of acceleration and therefore the time of rolling is affected by the moment of inertia of the revolving parts, but the variations in modern standard reversing mill drives from the values used in the preparation of the curves in Fig. 2 will produce no material changes in the results shown.

It is also interesting to note the effect of the variations in current limit on maximum speed attained during the pass as given in the following table:

Pass	Approximate Current Limit Setting Amperes	Maximum Speed During Pass RPM
a	9500	53
a	8500	42
a	7000	10
b	9500	67.5
b	8500	62
b	7000	52.5
c	9500	124
c	8500	116.5
c	7000	104

Appreciation of the importance of tonnage to American operators led us to adopt the shunt wound motor for driving reversing mills in preference to the compound wound motor so generally used throughout Europe, as well as to some extent in America. The machines are designed to commutate large currents, our current limits being set in 9,500 amperes and higher for 1,200 volt units. The changes in flux of the fields of the motors and generators have been carefully studied and the control so designed as to take to maximum advantage of the characteristics of each to produce rapid acceleration and retardation without in the least interfering with the complete control of the speed of the motors for rolling. Special means are provided for forcing the generator and motor fields to act quickly during acceleration and retardation. The magnet yoke as well as the pole pieces of the generator fields are laminated, to reduce to a minimum the effect of eddy currents in slowing down the acceleration and retardation. However, in spite of the complexity of the problem involved in the control of these large units, the system of control as finally worked out is readily maintained by the plant electrical department.

It is essential in entering any new field of application to include a larger factor of safety in the design of the equipment involved than is customary in established fields, and after our early reversing mill equipments had been in operation a short time, we appreciated that by certain minor changes in the control we could make a material reduction in the time required to accelerate and retard, and accordingly a complete series of tests were made at the works of the Trumbull Steel Company, having this in view. The Trumbull mill is a 36 inch reversing blooming mill driven by a standard 6 250 hp A. I. E. E. rated (5,000 hp, 35 degrees) 50/120 rpm dc reversing mill motors, having a maximum momentary capacity of 17,000 hp, at 45 rpm, and supplied with power from a 5,400 kw A. I. E. E. rated (4,000 kw 35 degrees) flywheel motor generator, consisting of two 2,700 kw A. I. E. E. rated dc generators and a 50 ton flywheel, driven by a 3,750 hp A. I. E. E. rated induction motor. Tests of this nature of necessity require a great deal of time, as one of the factors involved is commutation and intervals of several weeks and often months are required to determine, with any degree of certainty, the outcome of any change.

From examination of the curves taken on the Trumbull mill it will be found that the time required to reverse from 90 revolutions forward to 90 revolutions reverse was reduced from 4 seconds to 3 seconds, as a result of the changes which were made in the control. Practically all of this saving was made during the accelerating portion of the cycle, approximately one second being required to retard in either case. This reduction in acceleration time either shortens the time required for the mill to reach a given speed or makes it possible for the rolls to reach a higher speed during the pass, both of which increase the average speed during the pass.

These results compare very favorably with those obtainable with modern steam reversing engines under similar conditions, and any slight advantage which the steam engine may have over the electric motor in the rate of acceleration, as shown in Fig. 4, is more than offset by delays due to slowing down and frequent stalling as the steel enters in steam driven mills. This difference between the steam engine and the shunt wound mill is clearly shown by speed curves which are the speed time curves for the Trumbull mill and a modern steam mill. It was noted that it is approximately one second after the steel enters the steam mill before the engine has regained the speed at which it was running when the steel entered, while with the electric mill there is no drop whatsoever, as is shown by the Trumbull curve. It is here that the shunt wound differs from the compound wound mill motor, the latter dropping in speed as the steel enters although not to as great an extent as the steam engine. These curves are selected to illustrate the speed characteristics of the two types of drives rather than to indicate record speeds.

The developmental work which we carried on at the Trumbull mill, resulting in increasing the rate of acceleration of the motor beyond our contract obligations, we feel has fully repaid us for the time and expense involved, because of the reduction in rolling time and consequent increase in tonnage made possible by it as evidenced by some of the remarkable records made on this mill. The Trumbull Steel Company have rolled one 22" x 20" x 60" ingot weighing 6,700 pounds, down to a 6¾" x 6¾" billet, in 11 passes in 57 seconds and have rolled 57 of these ingots, 190 short tons, to the same final section in an hour, taking 13 passes per ingot to bring about the reduction.

DISCUSSION ON BLAST FURNACES.

At the meeting of the Southern Ohio Pig Iron and Coke Association, held at Ironton, August 24, the report of the rating committee was received, and the recommendation for the rule for rating blast furnaces was adopted. Charles R. Peebles, manager of the blast furnace department of the Ashland Iron & Mining Co., Ashland, Ky., is chairman of the rating committee, and submitted the report as follows:

Capacity of Blast Furnaces.

Regardless of grade of pig iron produced blast furnaces of modern construction should burn about the same amount of fuel daily under same operating conditions.

For each grade of pig iron the tonnage which can be produced will depend upon the quality of fuel used, yield of ore mixture, and blast temperature.

The tonnage of coke which can be burnt in a unit of time has a certain ratio to the working volume of the furnace.

From figures prepared on a number of different size furnaces it has been found that with good practice 60 pounds of coke can be burnt each 24 hours per cubic foot working volume. The working volume is taken as volume from center line tuyeres to two feet below bell closed.

Therefore, the capacity of a blast furnace must be expressed in terms of pounds which can be burnt per day. And, in order to cover variations which exist from time to time in operation it is necessary to adopt a base coke, a base theoretical yield ore mixture, and a base hot blast temperature and then make allowances for variations as encountered.

At a previous meeting the "base coke" adopted by the association was a coke containing 89 per cent fixed carbon with sulphur under 1 per cent.

The association also passed resolutions concerning the $10 detention charge on open top cars and cars loaded with coal, coke and lumber. This action has already been reported by telegraph.

MEETING SEPTEMBER 14.

The third annual meeting of the Southern Ohio Pig Iron and Coke Association was held at the Hotel Marting, Ironton, O., Tuesday, September 14. A large part of the membership was present and there were several guests from Chicago and the Ironton district. The following officers were elected: President, R. H. Sweetser, of the American Rolling Mill Company, Columbus; vice president for Ashland district, Charles R. Peebles, of the Ashland Iron & Mining Co.; vice president for Ironton district and Hanging Rock District, W. G. Sharp, of the Marting Iron & Steel Co.; vice president for Portsmouth district, W. R. Knapp, of the Portsmouth Solvay Coke Company; vice president for Hamilton district, Joseph F. Savage, of the Hamilton Furnace Company; secretary-Treasurer, F. P. Colville, of Eaton, Rhoades & Co., Ashland, Ky.

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Carbon Steel Company Jobbing Mill

New Mill Used for Rolling High Carbon and Alloy Steel Sheets and Plates at the Pittsburgh Plant of the Carbon Steel Company.

By J. F. BURT,
Westinghouse Electric & Manufacturing Co.

FOR the past several months, the Carbon Steel Company at their Thirty-second street plant, Pittsburgh, Pa., has had in operation a 32" mill possessing several interesting features. Contracts were let for the equipment just before the armistice, and it was the intention at that time to use it for rolling light armor plate for tanks and armored cars. However, it was not installed until after the war ended and has since been engaged in turning out high carbon and alloy steel sheets and plate almost exclusively. The installation consists of a jobbing mill with 32x64" roughing stand, and 32x56" finishing stand; and one roughing and one finishing stand of 32x38" sheet mill. The sheet mill is of the ordinary type excepting that all four stands are on the same side of the drive, the pinions being between the jobbing and sheet mills. The greater part of the mill proper, tables, slab buggy, etc., were furnished by the Mackintosh-Hemphill Company, who supervised the entire layout.

A 700 hp 220 volt 3 phase 60 cycle Westinghouse wound rotor induction motor drives the mill through a 10 to 1 Woodward double helical reduction gear unit. This gear unit has a 10' 6" diameter, 22,000 lb. cast steel flywheel mounted on each end of the pinion shaft, these two wheels having a stored energy content of approximately 23,000 hp seconds at rated speed of 320 rpm. The flywheels and gears are enclosed in a steel plate case. The motor drives the gear unit through a Francke double floating ring type flexible coupling.

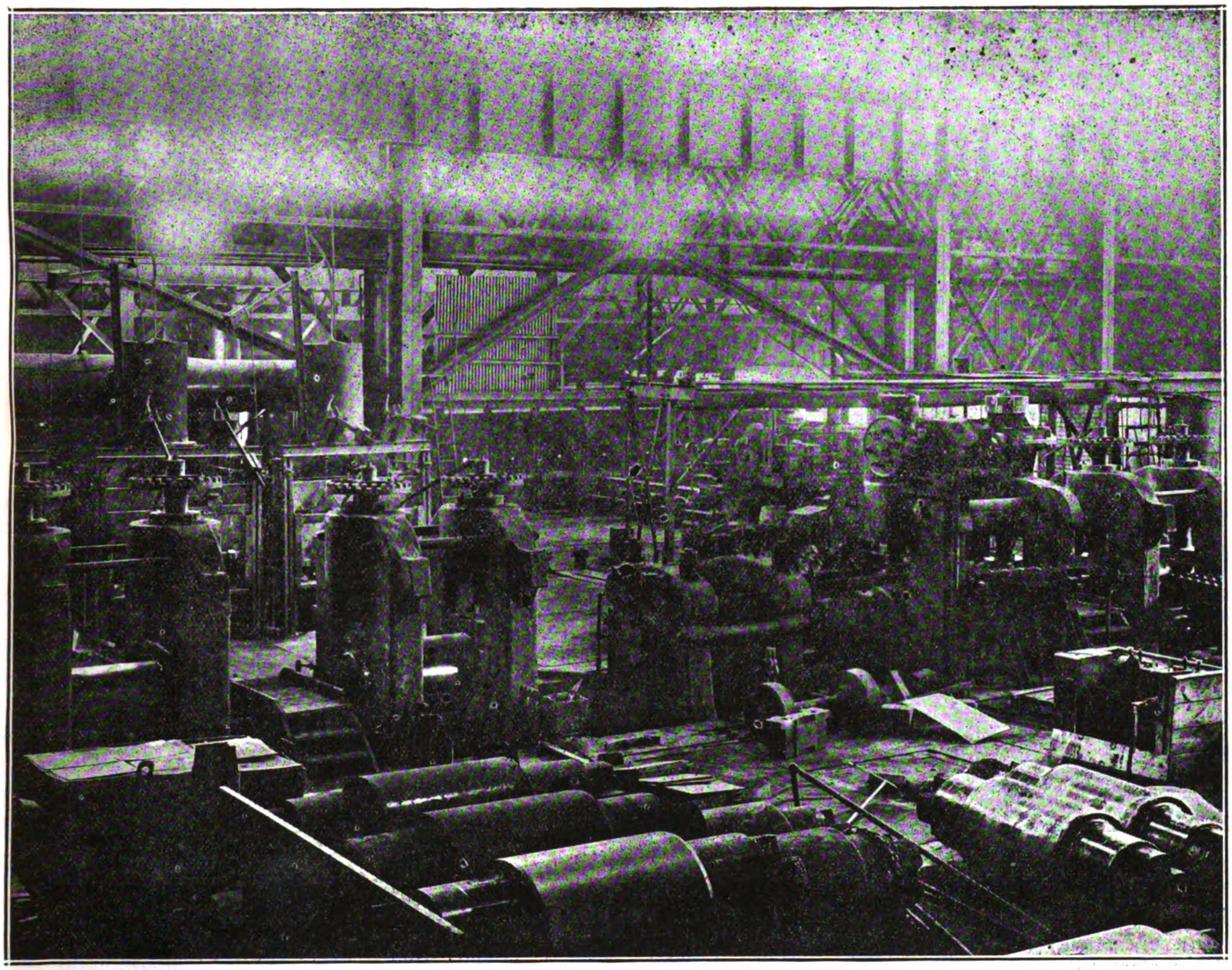

Fig. 1—Delivery side of 32-inch mill. The jobbing mill is at the right and the sheet mill at the left. The furnace and charging crane can be seen in the background.

A neat brick control room is located near the motor. This room contains the control for the main motor and also for the auxiliaries. The main motor secondary control is of the well known liquid slip regulator type,

which is especially well adapted to sheet mill drive. Power is brought to the motor through disconnecting switches and a double throw primary circuit breaker. The "reverse" side of the breaker is used in plugging the motor, to bring it to a quick stop. The usual indicating and integrating meters are mounted on the primary panel. The liquid slip regulator consists of moving and stationary electrodes immersed in a tank of electrolyte. A torque motor actuated by primary line current is so connected as to separate these electrodes, which are normally close together. The value of line current which will cause the plates to separate is adjustable. The secondary circuit of the main motor passes between the electrodes through the electrolyte. At some predetermined load, the plates start to separate, inserting resistance in the secondary circuit, causing the motor to slow down and allowing the flywheels to carry the excess load.

The jobbing mill is designed to handle sheet and light plate up to 48 inches wide, and 15 feet long finished. The metal is handled to a large degree by electrically driven machinery, the only hand manipulation being on the entering side of the main rolls, and on the entering side of the annealing furnace.

The slabs for this mill are charged into two six-door heating furnaces by an Alliance one-ton floor type charging crane, which also takes the hot slabs out of the furnace, and deposits them on the slab buggy. This slab buggy is a short length of roller table mounted on a track, and with the mill end considerably lower than the furnace end. A row of dogs projects up between the rollers when the buggy is at any except its discharge position. After receiving the slab, the buggy is run up to the mill by a remote controlled Westinghouse Type KG dc motor. Upon reaching the mill, the dogs automatically lower discharging the slab.

The 32x64" roughing stand has a 5" lift and is equipped with a motor driven screw-down. A motor driven lift table on the delivery side lifts the slab so that it can be easily pushed back over the top roll. The screw-down is operated by a 60 hp Westinghouse mill type motor, and the lift table by a 30 hp motor of the same type.

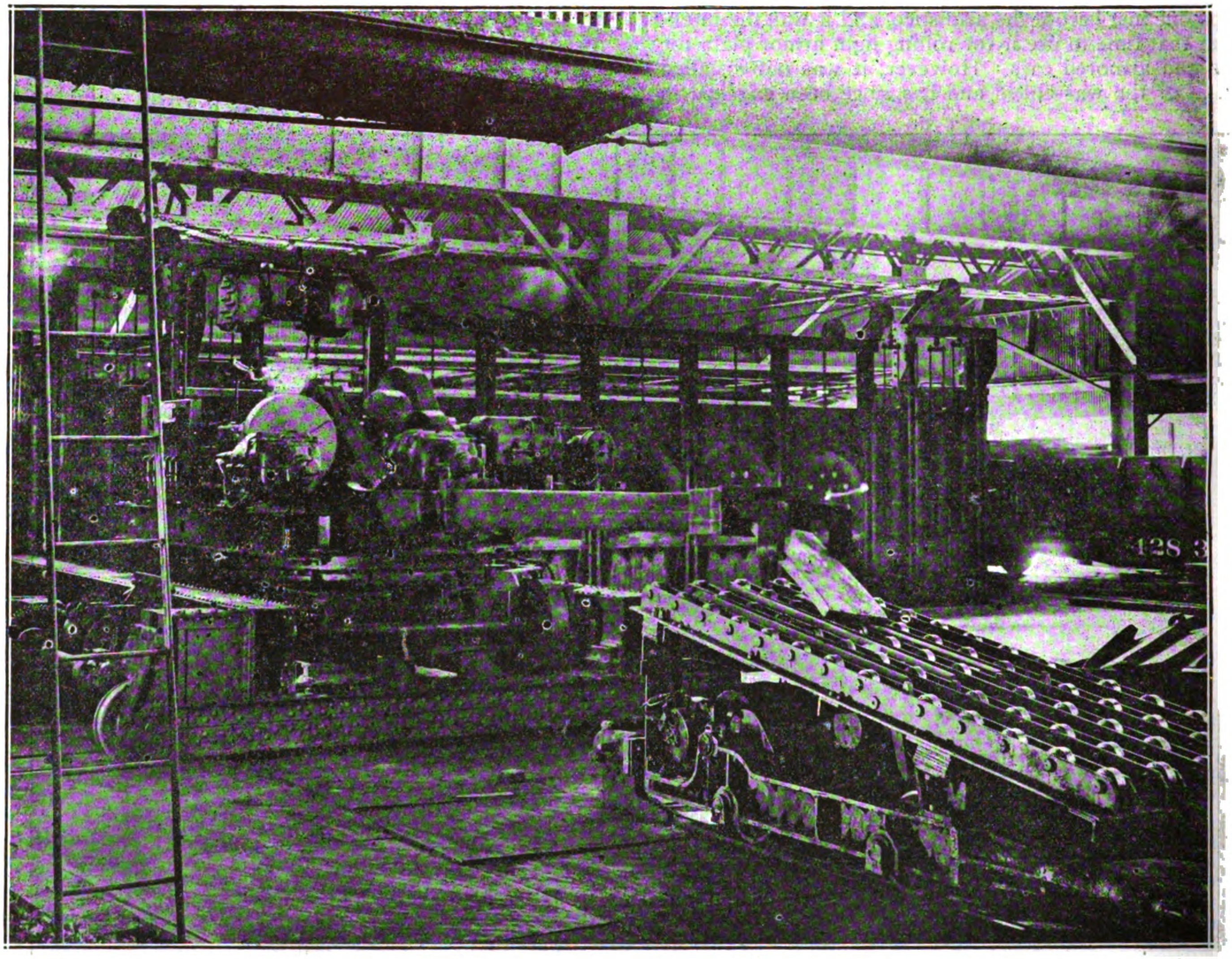

Fig. 2—Charging crane and slot buggy.

The piece is transferred to the finishing stand by means of hooks and tongs. This stand is equipped with a motor driven tilting table on the delivery side. After the required number of passes here the sheet is run into the annealing furnace where it is given a wash heat.

After passing through the annealing furnace, and an eleven roll straightener, it is deposited on a slow speed chain transfer, which carries it to the castor bed and

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shear.

Power for this mill as well as for the entire plant is furnished from the Duquesne Light Company. The utilization of central station power enables the mill management to devote their entire energy to the production of steel and allows of increased electrification without the additional expense of expanding an individual power plant.

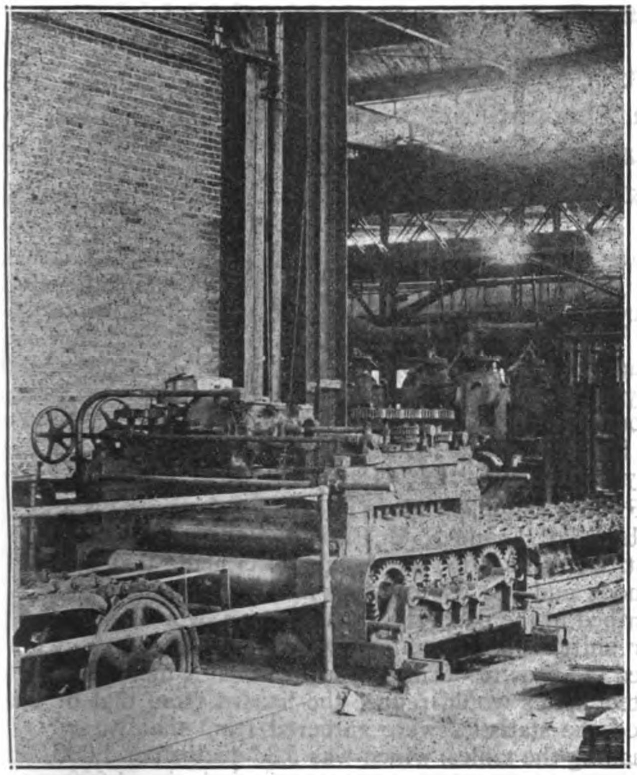


Fig. 3—Eleven roll straightener, looking toward the rear of the annealing furnace.

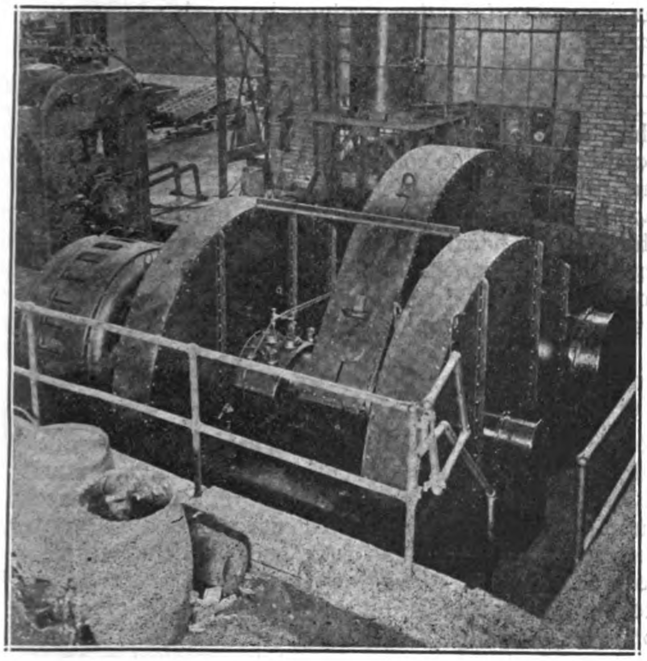


Fig. 4—Motor gear and unit. Jobbing mill and control room in background.

That is, by using power from a central station it is possible to increase the number of motors and other electrical appliances without fear of reaching a point where it is necessary either to stop adding electrical equipment, or to increase the capacity of the mill's power station by adding generators with the accompanying engines. In either event the proper course will depend on the dependable supply of blast furnace gas and on the possibilities of its use in other departments.

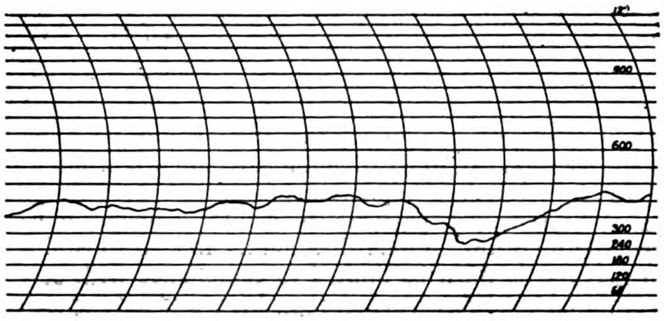
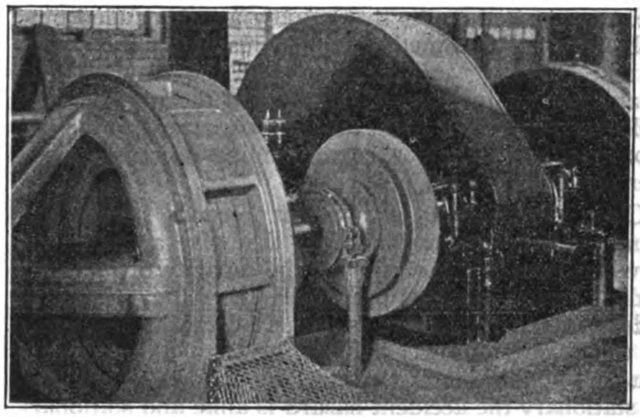


Fig. 5—Kilowatts input to GJJ hp motor. Jobbing mill rolling 48 inch wide plate, paper speed six inches per minute. Full scale deflection, 1200 kw.

USES MAGNETIC CLUTCH ON SYNCHRONOUS MOTOR DRIVE.

Synchronous motors are now used by many steel mills, foundries and iron works for driving pumps, fans, compressors, and other loads requiring a constant speed and necessitating infrequent starting and stopping. The synchronous motor is particularly desirable for this class of work, as it allows the power factor of the electrical supply system to be improved by over-exciting the motor field.

This type of motor, because of its extremely low starting torque, must be brought up to speed before it is connected to the load. After the motor reaches synchronous speed, a clutch between the motor and the load is engaged, thus bringing the pump or fan up to speed.



150 hp synchronous motor driving reciprocating pump through magnetic clutch.

The illustration shows a synchronous motor installation in the Petroleum Iron Works, Sharon, Pa. The motor is rated at 150 hp and receives power from a 2200-volt 3-phase supply line. A reciprocating pump for an accumulator comprises the load, and is driven by the motor through a reduction gear.

The clutch shown in the illustration is 30 inches in diameter and has a maximum torque of 2,410 lb. at 1 ft. radius. It was made by the Cutler-Hammer Mfg. Co., of Milwaukee, Wis.

Standardization of Electrical Equipment and its Relation to Accident Hazard

Standardization Demanded on Account of Economy in Construction and Operation and Equally so on Account of the Lowering of the Accident Hazard.

By WALTER GREENWOOD.

If standardization required for similar purposes, by whoever supplied, to be alike the most important incentives for securing improvements would in a large measure be removed, particularly would competition be destroyed; therefore, standardization as applied to equipment necessarily must be limited to compliance with certain requirements for securing ruggedness and safe operation. Secondary to this requirement must be efficiency, which involves maximum of output to the unit of labor employed. It is not alone in the matter of devising improved methods of construction and applying equipment for securing the maximum output that accident hazard is reduced to a minimum, but intelligent application of methods for operation of equipment is necessary.

Definition of the term standardization seems to imply it can be applied to principles and methods; whether or not we are right in such an assumption, when we use it in connection with methods of applying mechanical skill and in operating equipment, we are alluding to principles and methods that should be agreed to as the most desirable. Universal adoption of these must be brought out by consultation and agreements.

The person who seeks results feels bound to suggest a method for obtaining them, and without a good knowledge of all operating conditions is liable to make suggestions that cannot be successfully complied with.

However, the results that usually are demanded must be obtained by some method, so it remains for the designing and operating engineers to find the way. If the demand for an increase of product to the unit of labor employed is complied with, the limit of hazard to the unit of product must show a corresponding decrease that is inversely proportional.

Close observation of accident records reveal that when operating under conditions that give a stated output which does not severely tax the capacity of mills, the accident hazard remains practically the same. Speed up production and the hazard is higher; decrease production and the hazard is lower. Knowing it to be a fact that where all conditions and controlling influences are alike and stationary the accident hazard is alike and stationary, what then remains to be done to better conditions if betterment is desired? If guided by reason we must conclude that such changes of methods must be made as will increase the unit of output to the unit of labor.

The most common method for making comparisons to show increase or decrease of number of accidents resulting in personal injuries, during one period with another in one situation with another, is to ascertain the percentage of accidents to employes, considering also hours of employment. This method might be further refined by ascertaining the hazard during a long period in each kind of employment or each department of units, and use each hazard for a standard to measure the efficiency of the department it was obtained from, to ascertain whether or not it improves. This refinement of method is seldom if ever entered into. In some cases analysis of accident reports have been made by using the output of product for the basis of calculation. Where this has been done reports seem to give more accurate analysis of results than is given by other methods.

From a statement given in a paper that was discussed by the A. of I. and S. E. E., at the annual meeting held in St. Louis in 1919, the deduction is made that by such methods and the use of such mining equipment as was described in the paper, 18 tons per man, working an eight hour shift, could be mined where but three tons were mined, as shown. Mining coal by such a method in the United States would reduce the hazard from that of the period the statistics were gathered from that were used in making the tables, which was 5.83 deaths per 1,000,000 tons mined, to 1.67, or in place of employing 1,000 men to mine 3,000 tons 268 would be employed. Assuming the reduction in hazard to be in proportion to the reduction in labor, instead of 3.74 deaths per year per 1,000 employed we would have but 1.07. Of course, our deductions are based on calculations that did not consider the manifold variations in physical conditions attending the various localities used for comparisons, and while on that account the results shown by comparison with foreign countries are unfair, there cannot be much exaggeration when the results shown by comparison of methods and probable results in the same situation are considered.

The many influences that bear on the accident hazard in the various industries and in plants where operations are conducted, are too complex to be determined, but there seems to be justification for saying that where there is no variation in the influences there is but little variation in the accident hazard. After the greatest reduction has been made that can be made, through safeguarding and education, there still remains that practically irreducible average to the number employed. It cannot be denied that improvement in methods for efficient production of other staples than coal likewise lowers the accident hazard to the unit of product.

Unfortunately proper statistical information is not at hand to support the contention that standardization reduces the already reduced unit of accident hazard secured through increasing efficiency in production, but such analysis of results as have been made by those as have given thought to the subject which cannot be presented in a way that is indisputable for want of concise information bearing on all phases of the subject, is nevertheless convincing.

When we discuss electrical equipment used in the iron and steel industry, the term standardize should embrace

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Abstract of paper read at Association of Iron and Steel Electrical Engineers' Convention.

equipment that is auxiliary to electrical equipment in that it derives its energy from electrical equipment. This is the case with cranes, charging machines, ore bridges, etc., also with rolling mills, converters, etc., so far as driving the equipment connected with the operations is concerned. In the case of standards for cranes, they include quality, convenience, etc., also uniform arrangement of controlling parts should be included. Individually considered, hazard is reduced by quality in that breakage cannot occur unless capacity is exceeded; capacity cannot be overtaxed where control is properly regulated. Uniform arrangement of controlling parts, manually operated, reduces hazard by reducing liability of operating the wrong movement. Convenience reduces hazard by making situations and parts accessible. Interchangeability reduces hazard and is classified with convenience, but going back from the operating end, interchangeability simplifies construction and through efficiency in construction of interchangeable parts hazard is again reduced. Collectively considered, efficiency in maintainance reduces hazard. The same reasoning applies with equal force to all apparatus employed in producing commodities whether in the iron and steel industry or others.

Deductions based entirely on reasoning can be contradicted by other application of reasoning, but intimacy with results brings conviction that cannot be dispelled by reasoning from theories. Anyone familiar with operation of electric traveling cranes, and who also has had experience in revising heretofore constructed specifications for building them, should be able to see the importance of standardization as applied to their construction and method of operation, both for efficiency in producing and in reduction of accident hazard. Excepting as we are able to compare results where methods or apparatus have been changed from one form to another, we are not able to make comparisons that show what can be gained. When we are able to show profitable results from changes they should be made. To know when and how to make beneficial changes requires the work of consultation, which leads to standardization, usually because of its being economical. The most popular demand for standardization is made on account of economy in construction and operating. Equally with these, the demand should be made on account of lowering accident hazard; all are analagous to efficiency in increasing production.

Facts Concerning Auxiliary Drives

Factors Influencing the Selection and Application of Motors and Control—Relations of the Motor to the Machine and the Work to Be Accomplished.

By **GORDON FOX.**

ALL manipulating drives are more or less intermittent. They may be differentiated, however, as falling in two general classes, namely:

Running drives in which the duty cycle involves running an appreciable time at full speed, the starting and stopping being usually of lesser importance or entirely incidental. A few examples of this type or drive may be cited, as conveying tables, chain transfer, ingot buggy, slab buggy or other transfer car, crane bridge.

Start-stop drives, involving relatively short movements, in which the greater portion of the operating cycle involves accelerating or retarding the apparatus. Among the more common drives of this type may be mentioned the screw-down, side guards, manipulating fingers and main tables of a blooming mill.

In order to properly select and apply a motor and control we must first know and consider what the machine in question is to accomplish and what will be required of the motor in performing its portion of the task. One of the first considerations is the amount and nature of the load imposed upon the motor. This load demand is made up of several component elements, namely:

The work done by the driven machine in performing a useful function.

The work consumed in overcoming the friction of machine and motor.

The energy imparted in accelerating and consumed in retarding the moving elements of the machine and its load, including the motor armature, pinion, coupling and brake wheel.

It is desirable, as a first step in motor selection, to evaluate these elements of motor load.

The useful work may generally be quite closely calculated as a problem in simple mechanics, based, for example, upon lifting a given weight a given distance, shearing a given area or pushing a given stroke against a calculated opposing force. For many machines the useful work load is a relatively small item.

The friction load of machinery may vary materially depending upon condition of gears and bearings, alignment and lubrication. With the more modern mill machinery, however, favorable conditions are fairly well maintained and excessive friction loads are less common than in the past. Machinery of this type involves about the same friction load at all speeds, the variation due to speed being of lesser magnitude than other variables. It is possible to approximate by calculation the friction load of a proposed machine. For practical reasons it is preferable to estimate the friction load on the basis of comparison with similar machinery upon which data is available by test.

Machines which travel, such as a crane bridge or main trolley, involve the additional element of rolling friction. This may be of relatively large magnitude. As rolling friction varies directly with the speed, it is necessary in the case of such drives, to consider differing friction loads at different speeds.

The third element of load is due to the inertia which must be overcome in accelerating or retarding the motor and machinery. Inertia may be calculated from weights and dimensions or determined by comparison with known values of similar machines. This inertia may be first considered at the individual members, then translated into an equivalent inertia at a main shaft or at the shaft driven by the motor.

Inertia load involves change of kinetic energy. It

Abstract of paper read at the convention of the Association of Iron and Steel Electrical Engineers, New York City.

depends upon change of speed. It exists only in those portions of the operating cycle during which the speed changes. It is then present in amount depending upon the rate of change of speed. Rapid accelerating or retardation involves rapid change of kinetic energy and a heavy inertia load. It is thus evident that the inertia load of a machine is not a definite value. It is a variable depending upon the rate of change of speed.

Combining the component elements of load we have; a work load which may be a fairly definite value, a friction load of fairly definite proportions and an inertia load which is strictly variable. A motor size may now be tentatively selected which will cover the work and friction loads, and have sufficient margin to handle the inertia load. The margin required for the inertia load depends upon the nature of the work. For a running drive the work and friction load may well comprise 75 to 80 per cent of the motor rating. The rate of acceleration and retardation may then be restricted so as not to require more than the 20-25 per cent marginal capacity. For a start-stop drive a greater margin will usually be required to care for accelerating and retarding current. For this type of drive, the work and friction loads may be permitted to require about 40-60 per cent of the motor rating, depending upon the nature and frequency of the cycle. In the selection of motor size the continuity of the service should also be considered as a guide for use of the half hour, one hour or longer time, rating as a 100 per cent load basis. If a motor is to be called upon to repeat its cycle at very frequent intervals it may be desirable, as a later check, to approximate the heating load resulting from the combined periods of acceleration, free running deceleration and rest, comparing the result so obtained with the continuous capacity of the motor. If the motor is of insufficient capacity, a larger motor is required. However, if a motor is capable in all respects, excepting ability to dissipate the heat resulting from comparatively continuous duty, it may be desirable, in some cases, to ventilate the motor rather than install a larger motor. The justification of this procedure rests in the fact that the smaller motor introduces less armature inertia, which may lead to faster action and considerably reduced power requirement.

Having selected, at least tentatively, a motor size, the question of speeds may next be considered. For a running drive the full running speed is the consideration of importance. For a start-stop drive the ability to accelerate, develerate, reverse or spot the machine is ordinarily of primary import. The two types of drive should, therefore, be considered somewhat differently.

The desired, or required speed for a running machine can usually be stated by the machine builder or the operating superintendent. This may be checked to see that the machine will perform its function in the general scheme without introducing delay or limitation of output. We now know the machine speed desired. We have estimated the work, the friction loads and determined that they will impose, perhaps, 75 per cent rated one hour load on the motor. From the motor curves we may determine what motor speed will result with this loading. The gear ratio between motor and machine may now be determined as between desired machine speed and existing motor speed corresponding to the expected loading.

For a start-stop drive the accelerating and decelerating conditions are usually of prime importance. These considerations, rather than free running speed, should therefore, determine the gearing to be used. In selecting a motor for this type of drive a liberal margin need be allowed for starting and stopping currents. This capacity will be utilized in overcoming the inertia of the machinery and the motor armature and connecting parts. The moment of inertia of a machine at its main shaft is a definite amount, but its value at the motor shaft depends upon the fear ratio between motor and machine. The smaller the gear ratio (small difference between machine and motor speed) the greater is the amount of inertia of the machine as appearing at the motor shaft. On the other hand, the larger the gear ratio (wide speed difference between machine and motor) the faster must the motor revolve for a given movement of the machine, hence the higher the armature inertia introduced. For any set of conditions a definite gear ratio exists which will minimize the inertia load and permit most rapid acceleration or deceleration with an available amount of motor torque. Mr. Stratton has developed this formula in the A. I. E. E. proceedings, 1915. The formula may be repeated here as a basis of discussion:

$$r = \sqrt{\frac{I_1}{I_2} + \frac{(FR)^2}{T_2} \pm \frac{FR}{T}}$$

r = most favorable gear ratio between armature shaft and given shaft of machine.

I_1 = Moment of inertia of machine at given shaft.

I_2 = Moment of inertia of motor armature, (including pinion, coupling or brake wheel) at armature shaft.

FR = Torque at given shaft required to overcome combined friction and work loads.

T = Motor torque available during the accelerating period at motor shaft.

The item $\pm \frac{FR}{T}$ may be omitted if a drive is to be considered in which acceleration and deceleration are of equal importance. It is evident that friction and work load oppose acceleration and assist decceleration. For this reason the most favorable ratio of acceleration and deceleration will differ, the extent depending upon the relative amount of friction and work load. For drives in which quick acceleration is most desirable the item $+ \frac{FR}{T}$ should be used in the equation for most favorable gear ratio.

For drives where a quick stop is particularly desired, as for spotting, the item $= \frac{FR}{T}$ should be inserted in the equation.

The determination of values for the elements of machine and motor inertia, friction and work loads, has been already discussed. The evaluation of the element T, motor torque, may be briefly considered. The torque developed by the motor during an accelerating or decelerating period, depends upon the current passed through the motor. To evaluate T it is necessary to decide what current peaks may be permitted in starting or stopping the motor. From the current values the corresponding motor torques may be determined.

Having evaluated all the elements in the equation, the equation may be solved to determine the most favorable gear ratio. When this is done, it is well, as a check, to calculate the free running speed which will be reached by the machine if permitted to do so. This may be done by selecting from the motor curves the speed corresponding to free running friction and work load on the motor (40-60 per cent) and calculating the machine speed on the basis of the most favorable gear ratio as determined above.

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Corrosion of Coke Oven Walls

In England Coking Areas, the Corrosion of Coke Oven Walls Due to the Presence of Salt in the Coal Is a Serious Factor in the Life of the Oven.

By W. J. REES,
Lecturer in Refractories, University of Sheffield.

IN some of the coke-producing areas (for example, South Yorkshire and North Derbyshire) the corrosion of coke-oven walls due to the presence of salt in the coal is a serious factor in its effect on the life of the oven. In the Sheffield district, when deep coals are coked, this corrosion is very severe. In a particular case where coals from the following seams were being coked: The High Hazels seam, at a depth of 120 to 130 yards; the Barnsley seam, at 216 to 316 yards; the Parkgate seam, at 460 to 560 yards; and the Silkstone seam, at 540 to 640 yards; extraction by water showed 0.37 per cent of NaCl and 0.19 per cent of Na_2SO_4 in the unwashed slack and 0.18 per cent of NaCl and 0.08 per cent Na_2SO_4 in the washed slack as delivered to the ovens. With continued extraction with hot 10 per cent nitric acid, further quantities of both chloride and sulphate were removed from the slack, in several cases nearly 1 per cent of NaCl being extracted. The pit waters frequently used in the washery contain large quantities of dissolved salts, as shown in the following table:

	Pit water from pumping station	Water in circulation in washery	Drainage water from washed slack hoppers
	Grams per litre.		
NaCl	0.451	1.529	1.944
Na_2SO_4	0.149	0.524	0.768
K_2SO_4	0.052	0.062	0.072
$CaSO_4$	0.243	0.168	0.165
$MgSO_4$	0.357	0.264	0.261
$CaCO_3$	0.095	0.057	0.062
$MgCO_3$	0.051	0.041	0.023

and the question arose as to whether the use of a pure water, such as that of a town supply, would be advantageous. Laboratory experiments showed that there was little or no gain in either the rate of extraction or salt extracted by the substitution of either distilled or town's water for the impure pit water. The use of a purer water would, of course, result in some diminution in the quantity of dissolved salts sent to the oven, in the water adhering to the slack, but the expenditure involved would not be justified by the comparatively small reduction obtained. The rate of flow of water through the washery is a point which may be worth consideration where very salty coals are being washed, as with an increase in the rate of flow there will be a reduction in the concentration due to the solution of salts from the coal and a corresponding reduction in the salt content of the water adhering to the slack. In some pit and hopper drainage waters considerable quantities of magnesium chloride have been found and, in view of its ready hydrolysis, this may have an important effect on the coke-oven walls.

Taking the figures given above, there will be carried into the oven with each charge of slack and adhering water approximately 50 pounds of NaCl and 20 pounds of Na_2SO_4. The salt present will begin to volatilise at 800 degrees C. (to a small extent at lower temperatures, as salt has an appreciable vapor pressure at temperatures below its melting point) and in addition to this removal of salt by volatilization there will be some removed by hydrolysis as steam from the center of the charge comes in contact with the hot coal. The sodium sulphate present will also probably have some activity as a corrodant, as by interaction with the coal at the temperature of coking, sodium carbonate will be formed. H. V. Thompson,* in discussing the dissociation of salt, has shown that when a current of dry air is passed over molten salt at 1100 degrees C., the salt vapor carried forward by the air was 0.554 g. per litre. With a current of moist air, the salt carried over was increased to 0.0782 g. per l. The coking of wet slacks may thus be a factor of importance in cases of over-corrosion. The moist air with the salt vapor and the products of hydrolysis was then passed over (a) quartz chippings, (b) ferric oxide, (c) alumina, (d) clay. With the quartz there was a superficial attack only, a little sodium silicate being formed; with the ferric oxide, a little ferric chloride was formed, and there was, incidentally, a conversion of the bulk of the Fe_2O_3 into black crystals of Fe_3O_4; with the alumina, the attack was even less than on the quartz, a little sodium aluminate being formed. In the case of the clay, however, severe corrosion was observed, increasing with the iron content of the clay. In a paper recently communicated to the Refractories Section of the Ceramic Society† I have described a series of experiments in which the action of salt vapor (at 800 to 950 degrees C.) on silica, silicious fireclay, semi-silica and fireclay bricks was observed. The attack was, in general, much greater on the fireclay than on the other bricks.

The action of salt on clay has been extensively studied in connection with the prenomena of salt glazing, and this directs attention to an important difference between the conditions of salt-glazing and the conditions which result in the corrosion of fireclay coke-oven bricks. In salt-glazing, the kiln atmosphere will be much richer in salt vapor than a coke-oven at any period, but the salt is not applied until the articles to be glazed are at a temperature of about 1200 degrees C. At this temperature the salt immediately combines with the clay, forming a glass which coats the exposed surface of clay and protects it from any further attack by the salt vapor. The important factor in salt glazing is that the articles to be glazed shall be at the temperature at which interaction between salt and clay is rapid. In the coke-oven the conditions are essentially different, the internal wall of the oven never reaching the temper-

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Taken from the Journal of the Society of Chemical Industry.

*Trans. Ceramic Society, 1918; see J., 1918, 333A.

†Spring Meeting, 1920.

ature at which salt glazing is rapid. J. W. Cobb‡ has shown that interaction between sodium carbonate, alumina, and silica will take place at temperatures much below that of fusion of the mixtures, and it is evident that this type of reaction is important in coke-oven corrosion. In the coke-oven, the salt vapor instead of reacting with the surface of the bricks will penetrate them; there may be some deposition of salt inside the brick, but a good deal of the vapor apparently passes on until it reaches a zone in the brickwork at which the temperature is high enough for interaction to take place with some rapidity. The joint result of the slower interaction in the cooler portion of the brick and the more rapid action in the hotter zones is the formation of a weak, spongy mass which becomes increasingly open to the attack of the salt and which may fall away or be dragged away by the moving coal or coke. Another important phenomenon in connection with this corrosion is the very general presence of a layer of haematite in that portion of the brick where disintegration and shearing take place. This appears to be due to the formation and volatilization of ferric chloride by the action of salt vapor on iron oxide present either in the coal or more probably in the bricks. The ferric chloride vapor penetrates the porous bricks until it reaches a zone to which oxygen-containing gases from the combustion flues penetrate, and it is there oxidized with the formation and deposition of haematite. In this way layer upon layer of haematite may deposit until it reaches the thickness which may frequently be observed in old corroded bricks. The formation of ammonium chloride (and possibly also the presence of free chloride) may also be a factor in corrosion; the passage of ammonium chloride vapor over fireclay bricks at coking temperature shows only very slight indications of corrosion of the brick, but that continued action may result in the formation of ammonium or ammonia-alumino-silicates is evident from the action of ammonium chloride in the Lawrence Smith method for the determination of alkalis in silicates. Attempts have been made to prevent the penetration of vapors or increase the resistance to corrosion by facing or glazing the surface of the bricks, but up to the present these have been unsuccessful, the face falling away owing to the difference in the coefficient of expansion of brick and face.

The question now arises as to which is the best type of brick to use for coke-oven walls. When the coals to be coked contain little or no salt, it is probable that a good, well-burned fireclay or fireclay with silica grog (semi-silica) brick will be satisfactory, but in the case of salty coals the experimental evidence indicates that corrosion is likely to be much more severe on fireclay than on silica, alumina, or magnesite bricks. With an alumina brick the physical changes will, during use, be in the direction of continuous contraction, and, unless an electric furnace product such as alundum is used this type of brick is therefore ruled out. There is at present no quantitative evidence which indicates whether or not the high initial cost of alundum or magnesite bricks would be counterbalanced by the increased life of the oven. The physical changes in a silica brick during use are rather complex, the most important of them being the growth due to the gradual transformation to tridymite of the quartz in the brick. But if, in burning the brick, a maximum conversion of the quartz to the form of lower specific gravity is obtained, it is evident that the increase in volume of the brick during its subsequent use can only be small. Further, if by special grading of the raw materials and the formation of a suitable matrix, the recrystallization of the silica takes place so that the newly-formed crystals tend to interlace instead of to push against each other, the mechanical strength of the brick will be increased and its porosity reduced. The characteristics of the ordinary type of silica brick which render it unreliable for coke-oven use are its continued growth during use, its rather high porosity and its tendency to spall from the repeated changes in temperature; but it is now possible, by combining the two factors of suitable grading and adequate burning, to produce a silica brick with physical properties such as should make its successful use in coke oven practice a distinct probability. Such bricks are already being made and put into use in situations where corrosion trouble has been severe.

A factor which will be common to all coke-oven bricks in its influence on disintegration is that due to the deposition, in the pores of the brick, of carbon from the decomposition of hydrocarbons in the coke-oven gas or from the gases in the combustion flues. The reduction to the ferrous state of any iron oxide present and the possible formation of easily fusible ferrous silicate will also be a factor in the behavior and life of the brick.

The heat conductivity of the brick used for the coke-oven needs some consideration. This is so much affected by factors such as the temperature of burning, porosity, etc., that no figure short of that obtained by actual determination on a particular brick is of any great value. Experience in American coke-oven practice indicates that at coking temperatures the conductivity of a good silica brick is decidedly greater than that of a fireclay or semi-silica brick. This should be a further point in favor of the use of silica bricks in coke-oven construction.

RELIC OF DISTRICT'S OLDEST IRON FURNACE.

The oldest industrial landmark west of the Alleghenies is the remnant of the pioneer iron furnace erected on the banks of King's creek, Virginia, (now in Hancock County, West Virginia) more than a century and a quarter ago. It stands today beside the road in a state of picturesque decay. Large portions of its walls are still intact and the stones on the interior show the sears of hot flames. In the top of the furnace a tree has taken root and stands like a sentry living there to guard the ancient relic.

The furnace was built by a pioneer named Grant between 1790 and 1800, the exact date being in doubt, and was operated for several years by a company in which Grant was a partner. This firm failed and the enterprise subsequently was conducted by Connell & Tarr. Iron ore was found in paying quantities in the surrounding hills, and here also is a vast store of coal but the fuel of the pioneer furnace was charcoal. The forests on King's creek were stripped of their trees and the timber charred for the iron-making by the oldtime process.

The iron-mongers on King's creek began their work while the Indians still claimed title to the country and a number of pioneers were captured and several massacres took place about the time the manufacturing began.

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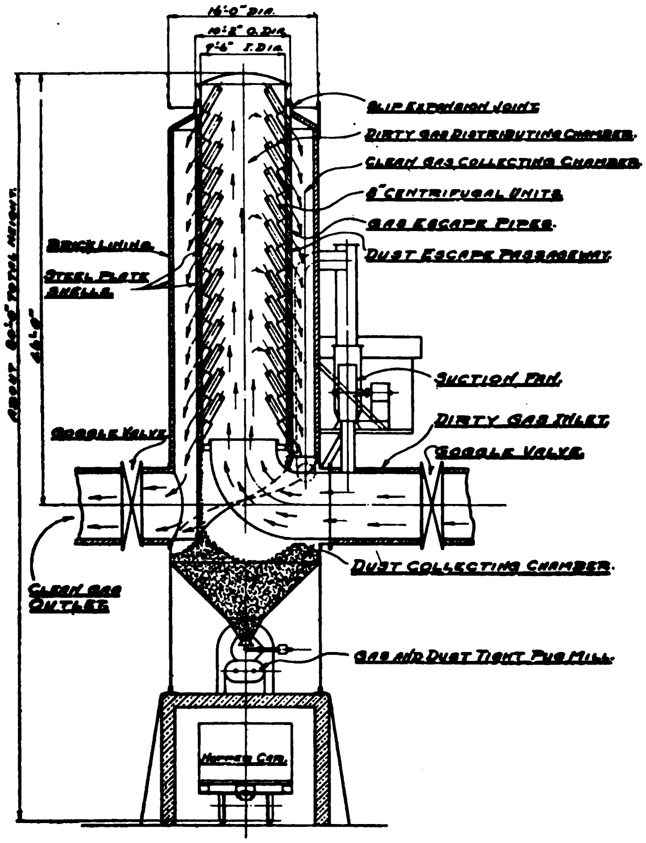
‡J., 1910, 69, 250, 335, 399, 608, 799.

New Multi-Centrifugal Gas Cleaner

A New Development Used at the Mingo and Bellaire Works of the Carnegie Steel Company Which Does Away With Losses Caused by Wet Washing Blast Furnace Gas.

By A. R. SCHULZE,
Asst. Chief Engineer Mingo and Bellaire Works, Carnegie Steel Company.

THE necessity of cleaning blast furnace gas for use under stoves and boilers has long been recognized by blast furnace operators and engineers, and in the lack of equipment which would perform this work under dry conditions, the various types of wet washers have been developed. Aside from the loss of sensible heat and the decreased plant efficiency, the other operating troubles are too many and too well known to require repetition now. The later developments in dry cleaning have the disadvantage of high construction cost, large ground areas and high maintenance.



MULTI-CENTRIFUGAL GAS CLEANER.
FOR
100,000 CU. FT. PER. MIN. CAPACITY.

A development by Mr. F. R. McGee, chief engineer, Mingo and Bellaire Works, Carnegie Steel Company, surmounts these difficulties and on test units, has given remarkable efficiencies. Fig. 1 shows a cleaner to handle 100,000 cubic feet of hot gas per minute, which can be installed in the gas main, or equipment can be designed to build into ordinary dust catcher, the rough cleaning and final cleaning then being completed in the one unit, with minimum heat loss, no sludge and no attendance. The cleaner consists of a number of centrifugal tubes of special design and covered by patents granted, these units in modified design being equally applicable to cement kiln gases, so that these gases may be cleaned and used under waste heat boilers, or the units may be installed in the boiler tubes themselves. Also for sinter plant gases, powdered coal gases, soot elimination, or for any form of solid or liquid particles carried in moving gas or air streams. The fan to rehandle about 5 per cent of the gases may be replaced by a venturi tube, eliminating all power driven mechanism, with no moving parts, attendance and maintenance are a minimum, the entire power for separation being furnished by the moving gas stream.

Head losses are small compared to efficiency, as shown by table of tests below, averaging from three to four inches of water. On fine blast furnace flue dust the best efficiency was made, an initial concentration of 5.2 grains per cubic foot being reduced to a final concentration of .121 grains per cubic foot. Equipment designed heavy and rugged, similar to best blast furnace practice, would cost about 60 to 70 per cent of prevailing types of dry blast furnace gas cleaners.

Table of Dust Collector Tests—McGee Cleaner.

Test No.	Dust used	Vol. air discharge cu. ft. min.	Initial concentration grains cu. ft.	Final concentration grains cu. ft.	Efficiency per cent	Back pressure inches water	Horsepower
3	Black press cake..	940	9.96	1.124	88.7	3	.87
4	Cyclone Collector Ore	940	10.05	.73	92.73	3	.87
17	Ore Dust.........	854	8.85	.283	96.84	2.98	.39
24	Coke Dust........	1150	1.96	.13	93.34	3.8	1.16
26	Raymond Mill....	770	7.55	.425	94.4	4.4	.89
27	Coke-ore Dust....	788	1.96	.13	93.34	4.4	.91
28	Raymond Mill....	1500	5.15	.339	93.45	3.24	1.28
31	Blast Furnace..... Fine Flue Dust	1559	5.2	.121	97.49	...	...
32	Fine Flue Dust....	1193	27.8	1.91	89.1	noz vel 40' sec	

Table Showing Fineness of Dust Used in Collector Tests.

	Passing 200 mesh screen	First Fraction	Second Fraction	Third Fraction
Black press cake......	94.9%	49.59%	30.56%	14.75%
Size in inches.........		.00029	.0017	.0028
Cyclone collector......	93.5%	32.04%	36.04%	25.34%
Size in inches..........		.00032	.0017	.0028
Raymond mill carbon.	53.28%	31.05%	11.72%	10.51%
Ball mill carbon.......	On 100 mesh 58.82%	On 200 mesh 21.94%	Thru 200 mesh 18.46%	

(Continued on page 572)

Test No. 32 there was considerable loss at eye of fan, per cent efficiency is actual weight recovered.

Current Limiting Reactances

Disadvantages of Centralizing Generating Equipment—Means for Aiding the Power House in Maintaining a Continuous Supply of Electric Power on Its Lines.

By R. H. KIEL.

THE present tendency in the production of electricity is toward larger generating stations, centrally located, and toward larger units in the station, so as to realize so far as possible the economic advantages of lower total capital investment, lower operating costs and better thermal and electric efficiencies, while still striving for maximum reliability.

In so many engineering problems we find a list of advantages and disadvantages arrayed against each other and the solution of the problem usually lies in a compromise, after the pros and cons have all been duly weighted. So we find that while there are many things in favor of centralizing our generating equipment and in increasing the size of the individual units, there are also some disadvantages which cannot be overlooked. Under normal conditions the concentration of a large amount of generating capacity on a single bus gives rise to no special difficulties. But at times of accidental short circuit in generator or transformer windings, on bus bars, or feeders, it may have very destructive effects. Oil switches may be blown to pieces in the attempt to open the circuit; generator and transformer windings may be badly distorted by the enormous forces acting on them; bus supports may be bent and insulators broken while even the cell walls may be cracked. The damage caused by severe short circuits may require considerable time and expense to repair. Even where all the equipment is sufficiently rugged to stand up under these strains without being damaged, the loss of voltage with the consequent dropping out of step of synchronous machines and loss of load is in itself a costly experience.

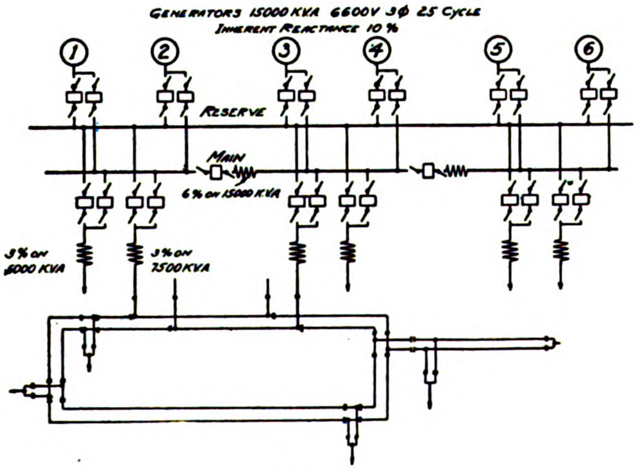


Fig. 1.

The processes in a steel plant are of such a nature that delay at any one point in the progression is usually felt all along the line. Production is curtailed and costs mount up. Elaborate precautions are usually taken to provide against delays. An immense amount of money is tied up in spare equipment and only the most rugged, and hence expensive, types of apparatus are used.

Since interruptions to the power supply are just as serious, while they last, as any other delay it becomes imperative to do everything within reason to assure continuity in the supply of power. It is customary to install spare generating equipment, double feeders to all important substations, and often duplicate busses, and switching equipment, so that in case of failure of any one of these important links, there may be equipment ready to immediately take its place.

Excellent as these schemes are in decreasing the delays due to short circuit disturbances or other electrical failures, none of them limits the amount of damage done to equipment at such times, either in degree or extent. It is the purpose of this paper to call attention briefly to still further means for aiding the powerhouse in maintaining a continuous supply of electric power on its lines.

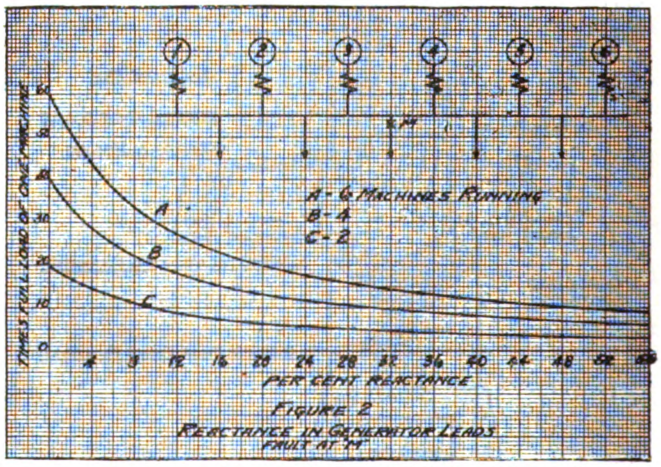


Fig. 2.

Reactance coils have been used in central stations and in some steel mill power houses, in several different ways to limit the amount of energy flow to a fault and to keep the current at times of short circuit to values well within the rupturing capacity of the oil switches used and to values which will not produce too severe mechanical strains on generator and transformer windings and on bus supports and connections. Reactance coils when used for power limiting purposes are usually of the air core type and are constructed of bare copper cable rigidly supported at frequent intervals in concrete, porcelain or wood supports. They are rated (a) in the kilovolt amperes absorbed by normal surrent, (b) by the normal cur-

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NOTE—Abstract of paper used at Association of Iron and Steel Electrical Engineers.

rent, frequency and line voltage for which they are designed and (c) by the current which they are required to stand under short circuit conditions. It is also common practice to rate them in per cent based on the kva of the circuit in which they are used. A reactance coil having a reactance of x ohms is said to have a per cent reactance of $\frac{100 \times I}{V}$ where I is the normal current and V is the total voltage across the circuit or the voltage to neutral in a three phase circuit. Stated another way it is the percentage ratio of the reactance drop at normal current to the total voltage impressed.

We will limit our consideration to the use of reactances in generator leads, in bus sections, and in feeders. Fig. 1 is a single line diagram of the particular system involved while later figures will take up in detail the various arrangements of reactors. Before considering any typical examples let us first briefly discuss the various locations.

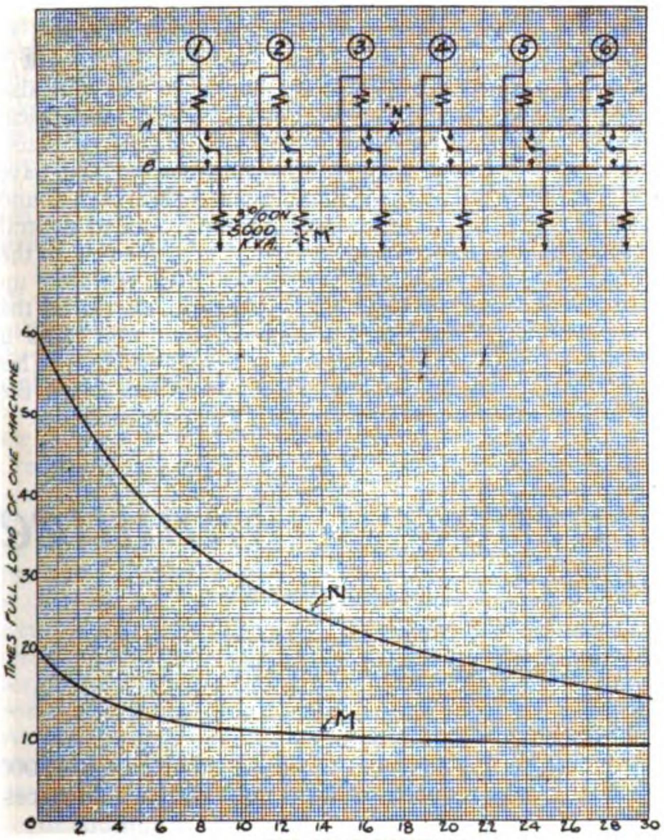

Fig. 3.

Generator Leads.

Generator oil switches are usually non-automatic and the amount of current which will flow at time of external short circuit is limited only by the amount which the generator can deliver. Every ac generator has a certain amount of inherent reactance in its windings and if additional reactance is inserted in the leads the current flow will be approximately in inverse proportion to this total reactance. This reactance then affords protection to the generator windings not only in case of an external fault but it also limits the flow of energy from other generators to a faulty machine before its oil switch opens. However, this location has its disadvantages, for it means that the reactors must at all times carry the full output of the generators and are therefore necessarily large and expensive. Beside, whenever there is a fault on any one bus section, all the generators of the good sections feed into the fault, each over its own reactors, and the consequence is that every section suffers the same drop in voltage, which of course is felt on all the feeders.

Bus Sections.

Bus sectionalizing reactances are very effective in limiting the current flow at time of short circuit while at the same time allowing the parallel operation of adjacent bus sections and the proper distribution of power over the different sections. At normal times they are called upon to carry only the current represented by what we might call the unbalanced load of the various sections or in other words the interchange of power from one section to another. This may become fairly large at times of light load when some units are idle and the entire output of some machines may have to be supplied over the sectionalizing reactances with a consequent drop in voltage between different machines. This is not likely to be at all serious in the steel mill where 24 hours operation is the rule. Oil switches are frequently installed to shunt the sectionalizing reactors at such periods of operation. Bus sectionalizing reactances are not effective in limiting the current flow from generators connected to the same section of bus to which the faulty line is connected. Bus reactors must necessarily be of large capacity and therefore expensive, but only a few of them will be needed.

Feeders.

Feeder lines are a more prolific source of short circuits than either the generators or busses. Sectionalizing reactances will limit the flow of current from sections other than the one to which the faulty feeder is connected, while if generator reactances only are used, the total current will be reduced but still all the generators will pump equally in the short and the entire system will be affected. If, however, we place reactances in the individual feeders they will be most effective and cause the least disturbance to the system, unless of course, the fault is not on the feeder. It is true that this means a large number of reactors but it also means reactors of comparatively small current capacity and enables one to use oil switches of relatively smaller rupturing capacity and lower price.

In Fig. 2 we have represented a single solid bus with 6 generators and several feeders. We have assumed a short at "M" either on the bus or on a feeder near the bus. We have taken various values of reactance in the generator leads and the curves give the values of current which would flow at time of short circuit. Three different conditions of operation are given namely; with two, four and six machines running. It might be said in explanation that only three phase symmetrical effective values have been used. To determine the stress on bus supports and windings it would be necessary to consider maximum and displaced wave as well as effective symmetrical values. For determining the duty on the oil switches we would also have to take into account the drop in current, which would take place by the time the oil switch contacts part and whether the generators were equipped with automatic voltage regulators, but these points were not regarded as within the scope of this paper. An arbitrary value of 10 per cent inherent reactance has been assumed for the generators in each case. This would be high for some 25 cycle turbo generators but serves the present purpose.

It will readily be seen that in order to limit the current flow to fault "M" to a value within the rupturing capacity of the feeder oil switch, say 20 times full load current of one machine, we would require 20 per cent external reactance. A study of Fig. 2 will show that if we use reactors only in the generator leads they will have to be of large current carrying capacity and high reactance value and will therefore occupy a large amount of space and will be costly. Then, too, there will be the disadvantage of the large drop in voltage at normal current across the reactor itself.

In Fig. 3 we have assumed an entirely different arrangement of bus connections. Bus "A" is merely a tie or synchronizing bus while the main bus "B" is sectionalized without reactors between the sections. Reactors are placed between each generator and the tie bus or what amounts to the same thing, between each main bus section and the tie bus. With this arrangement the generators feed directly onto the sections of the main bus but are held in synchronism through the reactors and the bus. With this scheme the short circuit values are the same regardless of which particular machines are operating, that is to say any grouping of two machines for instance, will give the same values as any other grouping. The reactors between busses do not normally carry much current but must have the capacity of one machine for if any main bus section is in trouble the whole output of the generator associated with it must go through the reactor belonging to that section. Also if only a part of the generators are operating but all feeders are drawing current, then those feeders which are connected to the idle bus sections must receive currents from the tie bus and consequently through the tie reactors.

An inspection of the diagram will show that in case of a fault on the tie bus all of the generators will feed into the fault in parallel each over its own reactor. Curve "N" gives the value of these currents for various values of reactances. It will be seen that the reactance values will need to be high to limit the current to stay as low a value as 30 times full load of one generator.

Curve "M" gives corresponding values for a fault at "M" on any 5,000 kva feeder assuming 3 per cent reactance in the feeder and various values in the tie reactors. It will be seen that the generator on same section as the faulty feeder will feed directly into the fault through one reactor while all others must feed through two tie reactors in series ahead of the feeder reactor. This is true of all feeders.

A great many other combinations and arrangements might be worked out but it is believed that sufficient examples have been given to show the results to be expected from the use of reactors in localizing and limiting the damage to a system at times of short circuit.

It will readily be appreciated that these reactors to be of any value must themselves be so built that they will not only overheat during normal operation but will also withstand the temperatures and the great mechanical stresses which are present when a short takes place. Reactors have not always been so constructed and have been known to fail at the critical time. It has been found in some cases that arcing grounds or ungrounded neutral systems, have produced oscillations at a rate equal to the natural frequency causing resonance and building up across the reactor voltages many times in excess of the line potential. Some reactors have been built with a resistance permanently connected across them. This introduces an energy loss which tends to cut down the oscillations and thus to prevent the high potentials.

Report of the Electric Furnace Committee

Report Giving Definite Recommendation Covering Installation on Furnaces and Accessories Under Special Conditions, Transformer Primary Voltage—Reactance—Variable of Dual Voltage.

By E. T. MOORE, Chairman.

FROM time to time the question arises as to what limit should be set on transformer primary voltage for electric furnace service. Transformers having a range from 22,000 to 50 volts are common and from the transformer standpoint, there is hardly any reason why the high voltage should not be doubled, tripled or even quadrupled. However, there are other factors that enter into the situation and in this case are the deciding ones.

As soon as we pass 22,000 volts, the type of oil switch necessary for safely rupturing the current changes to a design that is expensive to install and operate in electric furnace service. This is due to the large clearance required, especially with higher voltages, and trouble that may be experienced with impurities getting into the oil, such as carbon, from frequent operation, water, etc. Accordingly for 44,000 volts and higher, especially in small units, it is desirable to make the first step from the line voltage to 6,600 volts or 2,300 volts, depending upon the circumstances.

Two of many cases might be cited, in the first a 60 cycle 110,000 volt circuit was reduced to 6,600 volts for distribution to five furnaces while the other case a 44,000 volt circuit was reduced to 2,300 volts for two furnaces.

Automatic Control.

The task of keeping the power input to an electric furnace constant within reasonable limits by maintaining the position of several electrodes, with their supporting mechanism and flexible conductors, is not an easy one even when all arcing surfaces are comparatively stable, but when half of the arcing surface is made up of numerous pieces of metal constantly changing under the action of the arcs, the difficulties are considerably increased. From the surface of the molten metal there is a continuous spray of small metallic particles which make it easy to establish the arc before the electrode touches the metal but with solid metal the electrode must practically come in contact before the arc is struck and then it must be drawn away quickly so as to minimize the current surge. This is the condition met in the first part of melting down a charge of steel scrap and is a trying time to all parts of the equipment.

Automatic electrode regulators have been in use commercially in Europe for 25 years, and in this country about 15 years, in both places demonstrating to the user their value in effecting better results and conditions generally. The automatic regulator, not only maintains better conditions in the furnaces, permitting of greater power input in a given time with consequent higher tonnage, but also giving a much better load on the power house.

There are still those who believe in hand control, especially in small furnaces, either by requiring the operator to use his strength on the winches to raise and lower the electrodes or to direct the motion of the electrodes through levers controlling air or hydraulic cylinders or switches controlling electric motors.

An obvious consideration comes up when we consider the practice of paying a man to sit on a stool watching several meters and attempt to keep the power input within reasonable limits. The operator may do his best to meet the conditions imposed but it is only a matter of time when he becomes thoroughly fatigued by attempting to watch a meter needle in constant motion. Compared to the inefficient human machine we have a small relay that follows the impulses continuously and the automatic regulator throws a switch as soon as the change takes place in the circuit, the electrode moving almost instantly to meet the new conditions. If a furnace is operated 3,000 hours per year and the operator is paid $1 per hour there will be a labor charge at the end of the year to pay for at least one good regulator and leave something for installation.

In operating an electric furnace it is desirable to keep all surges within the closest reasonable limits as these surges have, in practically all cases, a definite bearing on the cost of power and, even when this is not considered, such surges affect other users and frequently cause prejudice against all electric furnaces. Momentary surges are limited by electrical characteristics of the furnace circuit while the duration of the sustained surge is determined by the electrode control. A sustained surge tends to carry the current density far above the normal carrying capacity of the electrodes, electrode holders, and conductors. As the heating varies directly with the square of the current, a current increase of 50 per cent will increase the heating 125 per cent above normal and accordingly shorten the life of any current carrying member, especially contact surfaces. The electrode consumption is also increased when the power is permitted to vary over wide ranges and surges tend to cause overheating at weak spots in the electrode with consequent deterioration.

In addition to the important consideration given above there are others of almost equal importance, such as the effect on the quality of the product due to widely varying temperatures at the surface of the metal, effect on the equipment, especially the transformers, due to surge strains, etc.

Partial success has been obtained in the automatic control of electrodes by air or hydraulic cylinders, but it is difficult to keep them in perfect condition and they are hardly up to the standard of electric motor drive.

Arrangement of Electrical Apparatus.

With several notable exceptions, practically all furnace equipments are installed in a straight line, that is the transformers are located directly behind the furnace and the direction of motion during tilting is directly away from the transformers. While this method of installation requires somewhat longer flexible leads, there are no side strains to the electrode masts and it is comparatively simple to install apparatus in buildings that were designed for other purposes. As opposed to this arrangement we have the design where the furnace tilts at right angles to the line from the transformers to the furnace. This arrangement requires considerably shorter flexible leads but giving considerable side strains to the electrode masts.

Where one polyphase transformer furnishes power to the furnace the bus bar layout is comparatively simple, but with three transformers it becomes much more complicated. In this connection comes the question of using interleaved busses to point where the delta or Y is formed and the flexible leads taken to the transformer, or whether this connection will be made at the transformers and the added inherect reactance accepted as a necessary evil.

The furnace conductors should be disposed as to avoid unnecessary eddy current losses which increase the reactance and may cause trouble through distortion of the iron work. Care should also be taken that the panels are kept outside of any magnetic loops or fields as the instruments may be unfavorably affected.

Bus bars are usually self-cooled, but an unusual exception is found on two 10-ton furnaces at Buffalo, where the connections from the cables to the electrode holders are thick walled water cooled copper pipes. These conductors have given good service during several years operation.

Flexible cables are necessarily used between the transformer and furnace busses and a form of insurance is the use of welded terminals that absolutely do away with shutdowns caused by failure of soldered or brazed terminals.

The current density is usually somewhat higher in the cables, approximately 900-1,000 amperes, than in the bars which usually run 750-850 amperes per square inch.

On account of the height of the electrode masts, in those cases where the conductors are carried over the tops, a saving in bus copper can be effected by raising the transformer on a pedestal so that the top of the low voltage leads in on a level with the top of the masts.

Variable or Dual Voltage Control.

An important subject is the use of double voltage operation for arc furnaces, not only from the standpoint of range of voltages to be used but also the possible detrimental effect of increased rate of melting, obtained by the use of such voltages, on the quality of the metal.

With small furnaces up to one or two tons capacity, except in special cases, there seems to be little reason for going to the expense of installing apparatus for double voltage control. In larger furnaces, however, there seems to be a good reason for using a high voltage during part of the melting period and a lower voltage during the refining period. With a furnace taking 1,500 kva the voltage applied to the electrode must necessarily be a compromise between a value that will not be so high as to damage the roof and side walls during refining, or so low as to lose too much time during melting.

By the use of double voltage control a voltage can be chosen for melting that will give the best results for this socalled heavy duty work while a corresponding value can be chosen for the refining which will give the best results during that important period.

In one installation the greatest power input that could be obtained during the melting down period was 1,800 kw at 100 volts while with practically the same furnace design the power input was increased to 3,200 kw by a moderate voltage increase.

There is a well defined belief that the high rate of melting, obtained by high voltages, is detrimental to the quality of the product, especially for tool steel, and this should be carefully investigated. Until the arc shows above the metal, there can be no other objection and possibly the same holds true for the quality of the metal.

Reactance.

The amount of reactance to be used with an electric furnace; its disposition, on high voltage or low voltage side; the amount of inherent reactance in the transformers; the kind of reactor, iron core or air core; depend upon the type of furnace, the service and local conditions. The reactance stabilizes the arc and determines the limit of short circuit current. The resistance of the leads, electrodes and charge being small compared to the reactance, can be neglected in this connection.

Amount.

Power factor and reactance are intimately connected and considerable harm has been done by advocating too high a power factor.

Public reference was recently made to the unsatisfactory operating characteristics of a 3 ton, 3 phase, 1,000 kva furnace taking power from a 11,000 volt, 25 cycle circuit. On account of the low reactance of this equipment, it is common occurrence for the oil switch to open several times during a heat and as this switch is set at six times normal current a reactance of approximately 16 per cent is indicated which should give a power factor of over 98 per cent, a figure unnecessarily high.

If the reactance was doubled, the power factor would be still approximately 95 per cent while the short circuit current would be decreased from 600 to 320 per cent. If the reactance was still further increased to 43.6 the power factor would still have the excellent value of 90 per cent and the short circuit current would be 229 per cent. This seems to be a desirable value although if still better protection is desired, such as on a small capacity privately owned plant, a reactance value of 53.7 per cent would give a power factor of 85 per cent and a short circuit current of 190 per cent. These figures are based on values that would be obtained with a reactance having a characteristic of the air core type and would necessarily be altered for iron core reactors and reactors of the compounding type, such as saturated reactors.

A 6 ton 3 phase furnace having transformer capacity of 1,500 kva on a 60 cycle circuit will have approximately 90 per cent power factor, indicating a reactance of 43.6 per cent, of which about 6 per cent will be in the transformers. The remaining 37.6 reactance, which is principally in the secondary leads, would be reduced to 15.7 per cent on a 25 cycle circuit. The 25 cycle transformer would have a reactance of about 7 per cent, which added to the 15.7 per cent, would give a total of 22.7 per cent, indicating a power factor of 97.4 per cent with a corresponding short circuit current of 440 per cent. This indicates that to give the smooth operation of a 90 per cent power factor furnace a 20 per cent reactance should be added to a furnace that normally required no exterior reactance on a 60 cycle circuit.

Primary or Secondary.

Except on small furnaces, or very high voltage circuits, the use of external reactance is practically confined to the high voltage side. In this location it gives additional protection to the transformer against exterior surges and is easier to install on account of the general arrangement of apparatus.

Transformer Reactance.

The inherent reactance of a transformer with normal design is from 4 to 7 per cent and this can be increased without much difficulty up to 20 per cent. If additional reactance is to be installed and it comes within this value, it appears to be a mistake to keep down the transformer reactance and then increase the installation cost by adding external reactance. This is not necessarily the case as the equipment will be considerably more flexible if the inherent or uncontrollable reactance is reduced to a minimum and desirable characteristics obtained by the use of external or controllable reactance. This is especially true in installations using variable voltage control as the amount of reactance necessary to produce the best results at the high voltage would be excessive and produce undesirable characteristics at the low voltage.

Type of Reactor.

Under ordinary circumstances the choice of reactor lies between the iron core type and the air core type, in some cases there being little to choose from the standpoint of price alone.

Air Core Reactor.

From the standpoint of protection the air core reactor is superior, as the reactance volts per ampere is practically constant throughout the capacity of the equipment. There being no iron present in the magnetic circuit, its characteristic curve is a straight line; that is, its reactance voltage increases in exact proportion to the current, regardless of the value of same. Furthermore, as there is no hysteresis, the flux does not lag behind the current but is always exactly proportional to it, and the full value of the reactive effect is realized.

Iron Core Reactor.

With this type of reactor the reactance volts per ampere is highest at low values of current and lowest at high values of current, a condition that should be exactly reversed to give the most desirable results. The air gap improves the operating characteristics of the reactor, helping to reduce the magnetic saturation of the core through the current range for which the reactor is designed. The effect of the hysteresis in the iron core is to cause distortion of the wave of reactance voltage which is practically equivalent to a time-lag, thereby reducing the effectiveness of the reactor in maintaining the arc as the supply voltage approaches the zero value of its cycle.

The iron core reactor is chiefly used in circuits carrying currents of less than about 50 amperes, when a reactance of more than 4 or 5 per cent is required. Under such conditions an air core reactor would require a very large number of turns to give the desired reactance, and the iron core design is considerably more economical. A characteristic curve for an iron core reactor, and obviously, for current limiting purposes should be designed so that its entire working range will fall below the "knee" of the curve. This type of reactor may be air or oil insulated, and is usually self-cooled.

This brings up a subject which is being given careful attention by a number of investigators and will doubtless lead to important results in the near future. For example, it is hardly necessary to point out the advantages that would be obtained from a reactor which would have, say, 15 per cent reactance at normal current and 75 per cent reactance at 200 per cent normal current.

PROGRAM

First Meeting of
AMERICAN ENGINEERING COUNCIL OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES.

New Willard Hotel, Washington, D. C.

November 18-19, 1920

Thursday, November 18, 1920.

Morning Session.

8:30 o'clock—Registration.

10:00 o'clock—Opening Session of American Engineering Council.

Call to Order,

RICHARD L. HUMPHREY,
Chairman, Joint Conference Committee,
Consulting Engineer, Philadelphia, Pa.

Election of Temporary Chairman.

Election of Temporary Secretary.

Appointment of Temporary Committees

(a) Program
(b) Credentials
(c) Constitution and By-Laws
(d) Nominations
(e) Plan and Scope
(f) Budget
(g) Resolutions.

Afternoon Session.

2 o'clock

Address—"Engineering Council."

J. PARKE CHANNING, Chairman.
Consulting Engineer, New York, N. Y.

Discussion of the Field of Activity for the Federated American Engineering Societies.

Friday, November 19, 1920.

9 o'clock—Morning Session.

Report of Committee on Nominations.

Election of Permanent Officers.

Report of Committee on Constitution and By-Laws.

Formal Ratification of Constitution and By-Laws.

Report of Committee on Plan and Scope.

2 o'clock—Afternoon Session

Report of Committee on Budget.

Report of Committee on Resolutions.

8:30 o'clock—Evening Session.

Introductory Remarks by Presiding Officer, the President of American Engineering Council.

Address ....
HERBERT C. HOOVER,
President, American Institute of Mining and Metallurgical Engineers, New York, N. Y.

9:30 o'clock—Informal Reception and Smoker.

Saturday, November 20, 1920.

9 o'clock.

Organization Meeting, Executive Board, American Engineering Council of the Federated American Engineering Societies.

Heating Furnaces and Annealing Furnaces

Furnace Doors—How Lining Is Held in Place—Effect on the Door of Pressure in Furnace and Escaping Flame—Difference in Doors for Annealing Furnaces and Those for High Temperature Furnaces

By **W. TRINKS.**

PART XXII.

DOORS for heating furnaces and for annealing furnaces consist, with very few exceptions, of metal frames which are lined with a refractory material. By far the greatest number of furnace doors is of the lifting type. Hinged doors are seldom used except in small sizes or for box annealing furnaces in which the material stays for several days. There are two objections to hinged doors. One is, that with a hinged door, it is impossible to heat a piece that is to be partly in the furnace and partly out of the furnace. The second objection is that hinged doors loosen the refractory material on account of slamming to which they are, as a rule, subjected in closing.

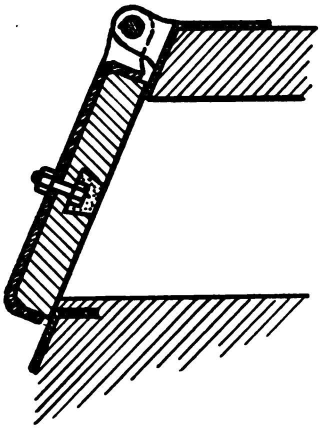

Fig. 156.

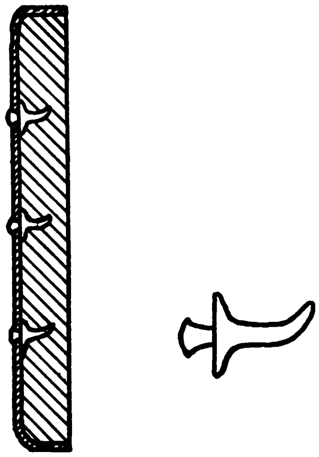

Fig. 157.

In many small furnaces the first of these objections does not exist, and the second objection is overcome by using a single tile for the refractory lining of the door. The tile is frequently held in place by two or four bolts as indicated in figure 156. The bolts hold the tile firmly against the door frame.

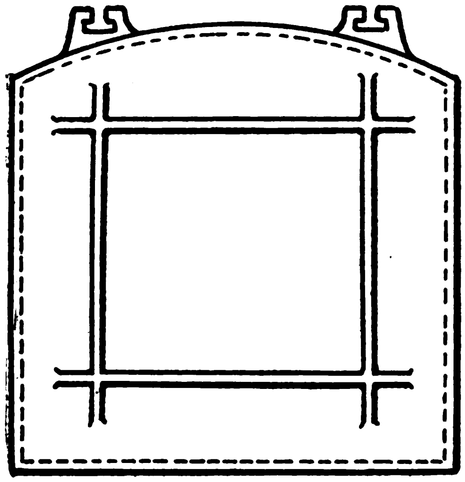

Fig. 158.

The frames of lifting doors must be strong and rigid enough to carry the refractory, and to withstand the warping of the heat expansion of the furnace-side-layers of the lining. The refractory material should be very thick, so as to minimize heat losses, and yet the weight of the door should be small, so as to oppose little frictional resistance to opening and closing. For high temperature furnaces (above 1800 F.) another circumstance must be considered, viz: That furnaces are as a rule operated with a slight pressure and that in consequence, the edges of the door frame are exposed to the action of the flame.

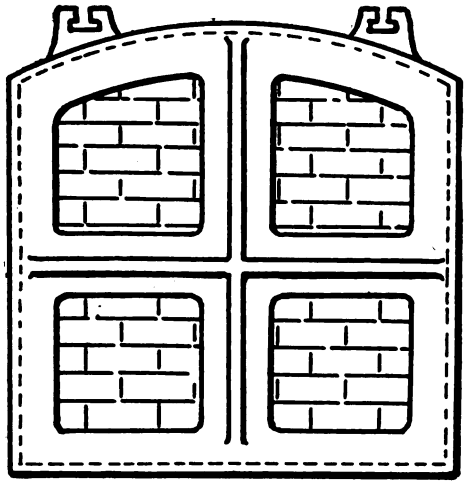

Fig. 159.

In annealing furnaces and in heating furnaces, that is to say for temperatures not exceeding 1600 F., a good compromise for the various requirements is obtained by the use of Sil-O-Cel as the refractory material. Celite powder is mixed with sufficient plaster of Paris to give the mixture strength. The mass is held in place by hooks which are cast into the cast iron framework. On account of the good insulating qualities

Fig. 160.

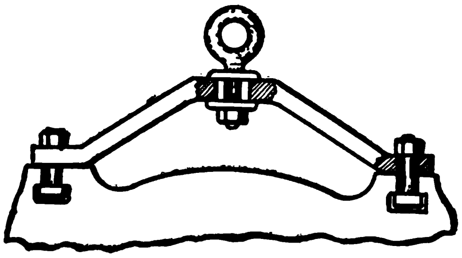

Fig. 162.

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of Sil-O-Cel, 2½ to 3 inches suffices. Furthermore, its specific gravity is so low that the whole filling is very light. The door frame can, therefore, be made very thin, just thick enough to hold the hooks. A thickness of ⅜ of an inch is sufficient for small doors, say up to 9 square feet of area, while for larger doors, the thickness must be considerably increased.

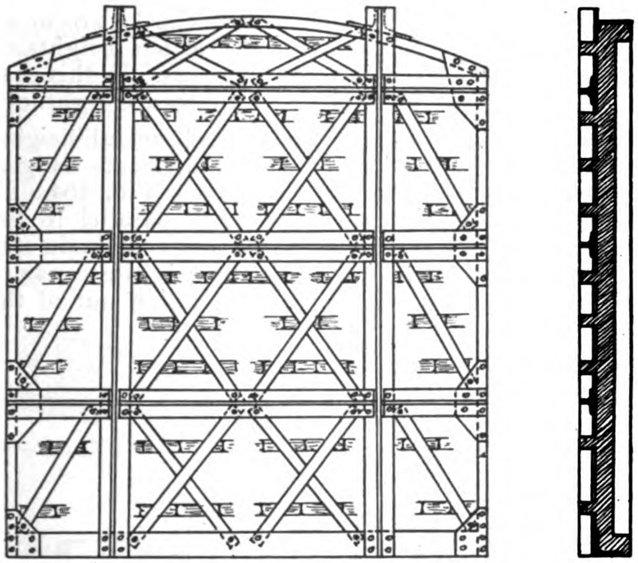
Fig. 161.

Doors for high temperature furnaces are invariably lined with firebrick, and the latter become loose, catch, and drop out. Taking material out of a hot furnace, when the door is open, is a disagreeable task and workmen in their hurry to remove the material from the furnace frequently catch hold of the bottom of the door, pull it away from the furnace and then let it slam back against its seat. Very few door fillings withstand this treatment for any length of time.

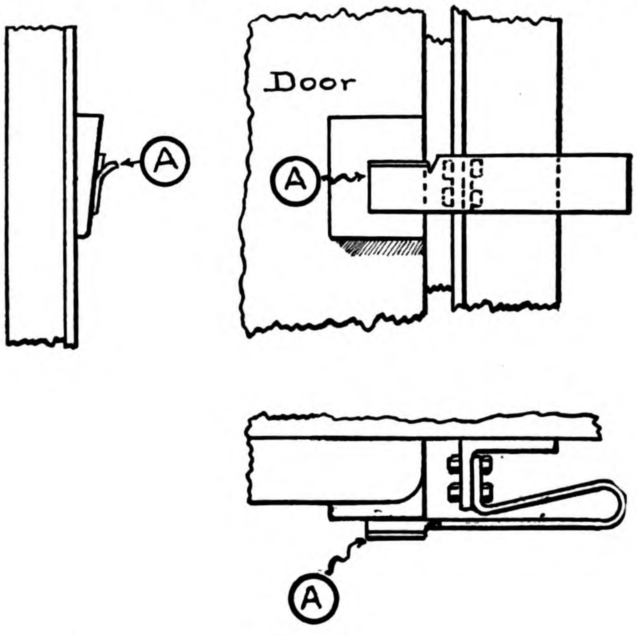

Fig. 163.

Cast iron door frames are either solid or open, see Figs. 158 and 159. Designers prefer the open type, because it is lighter, while heaters prefer the solid type because it allows operation until the week end even after a large part of the filling has dropped out. On the other hand, designers claim that the solid door hides the defects and frequently goes over the week-end without being repaired.

In either type, bricks are held more firmly, if the edges of the frame converge, as shown somewhat overdrawn in Fig. 160. Evidently the binding frictional force depends upon the force with which the bricks were pushed into place, and upon the size of the door. In doors of large extent the binding force does not extend into the center. The just described mothod of holding the bricks in place is not common because the door becomes a cored casting instead of a plain greensand casting.

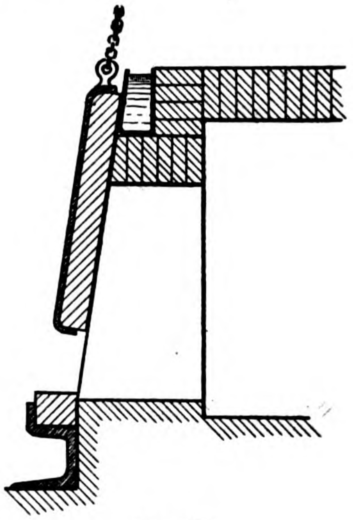
Fig. 164.

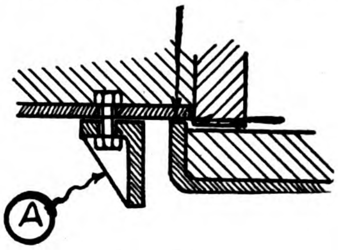

Fig. 165.

It appears that bricks in doors should be laid in a high temperature cement, such as Adamant, Hytempite or similar cements.

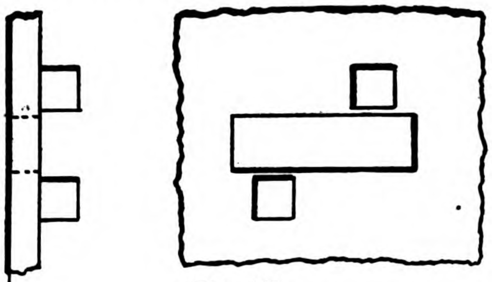
Fig. 167.

As a rule, doors are made 4½ inches thick, for the sake of lightness. The heat loss through doors is, in consequence, quite high. It is reduced by placing a 2½ inch thick layer of Sil-O-Cel brick between the fire brick and the door frame. If the latter be of the open type, the Sil-O-Cel brick is backed up with sheet steel of about 16 gauge.

Doors exceeding 36 square feet in area become very heavy if made of cast iron. Besides, they are unreliable on account of casting strains and moreover it is very difficult to hold the bricks in a large door. Finally, warping of large doors cannot be entirely prevented. All of these difficulties and objections are overcome by the structural door shown in Fig. 161. The door is light for its size and, of course, has no initial strains. The brick is set back except at the rim, so as to prevent catching due to warping. Although the door is only 4½ inches thick, 9-inch bricks are used at frequent intervals and are cut in to hook over the lattice work. They can move neither in nor out and hold (by friction or cementing) all the rest of the brickwork. The only objection to this door is its small thickness. It may be made more resistant to heat flow by plastering the outside with a mixture of Sil-O-Cel and plaster of Paris and holding the mortar in place by sheets of steel.

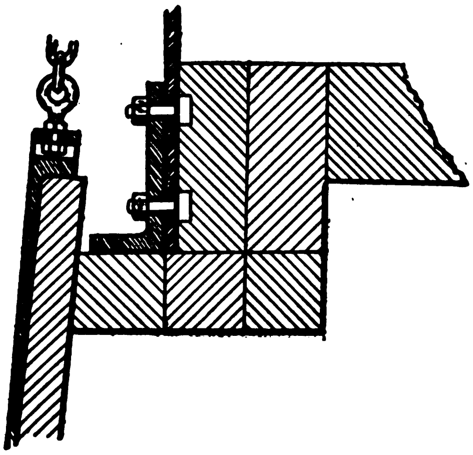

Fig. 166.

It is difficult to suspend doors so that they will close tightly, unless adjustments are provided. A door that is lifted by two chains needs only an in-and-out adjustment, but a door lifted by one chain only needs also a right and left adjustment. Ordinarily, adjustment is obtained by branching one chain in two, but a much better method is shown in Fig. 162. T-headed bolts sliding in slots provide for in-and-out adjustment, while an eye bolt with a larger washer, sliding in an oblong hole, provides for right and left adjustment. The cross bar must, of course, be made strong enough to carry the weight of the door. In spite of the most careful hanging of doors, it is difficult to make them close tightly. And yet the latter is certainly desirable because imperfectly closing doors contribute very largely to the speedy destruction of a furnace. The purpose of holding doors tightly against the frame is served by door-checks. A good and inexpensive door-check is illustrated in Fig. 163. A wedge shaped face-piece on the door contacts with a long leaf spring which is cut and bent to secure safe entrance, even if the door should hang away some distance from the frame. A spring check of this description is much better than a solid door check. The latter breaks off sooner or later, due to sudden or abrupt lowering of the door. Door checks are of no use with doors which work with various heights of opening, such as doors in forge furnaces. In this case some other force must be used to secure tightness.

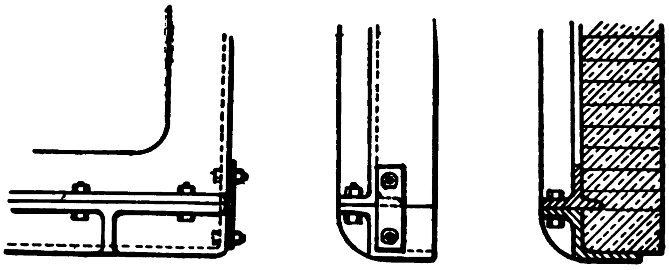

Fig. 168.

A force which works equally well in all heights is gravity. It is applied for tightening doors by giving the latter a slight inclination, see Fig. 164. In that case the lifting chain must pull parallel to the face of the door, and the latter must slide in the frame. If brick slides on brick there is the constant danger of catching and ripping the lining out of the door; and if metal slides on metal, there is the danger of burning these slides away. This is true because all correctly operated furnaces work with a slight pressure even if the latter be only .03 inches to .05 inches of water, which pressure is sufficient to throw a flame out of all openings. On the sides this condition can be taken care of as indicated in the partial plan view Fig. 165. The sliding surface is marked by arrows. A broad surface of refractory brick shields the fit. In spite of the protection against radiation, there is danger of burning out the door frame because flames leap out. The metal at this place must therefore, be so thick that the heat can be conveyed quickly to points from which it can be quickly radiated away. A heavy protecting strip (a), keeps the flame from playing against the buck-stays.

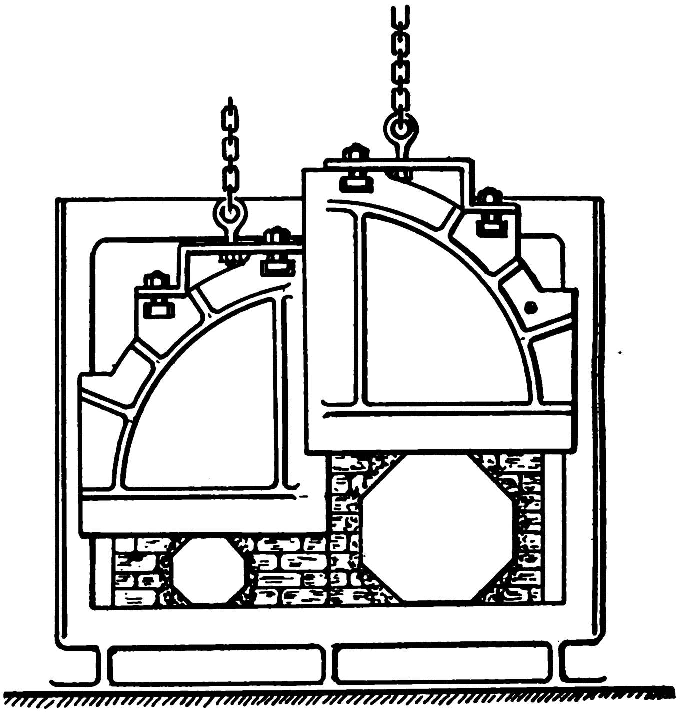

Fig. 169.

While this arrangement works well at the sides, it cannot be used at the top. There, one of two things is done. Either a water cooled trough is used as indicated in Fig. 166, or else a removable top piece is

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provided in which the door frame tightens against large tiles with few joints. Occasionally the tile is omitted and the brick of the door rests against the brick of the door arch. In that case the seal is very imperfect and a more or less wide opening is left for the escape of flames. It is advisable to set the furnace-front back as shown in Fig. 166, and to provide a heavy removable piece (a). This latter must be removable because it finally burns out, and it is made of heavy section for the purpose of carrying the heat away to places where it can be radiated away. The bolts in all parts which are exposed to the flame burn in so tightly that they can only be removed by being chipped off. The protected end of the bolt should be T-shaped and should fit into a slot with lugs on the back side of the casting so that the bolt can be easily inserted or removed, see Fig. 167.

In general, the bottom of a furnace door gives comparatively little trouble. An exception is made by the doors of forge furnaces. In order to heat the steel all of the way to the door, a forge furnace is operated with so much pressure that flames pass out at all time around the billet or ingot.

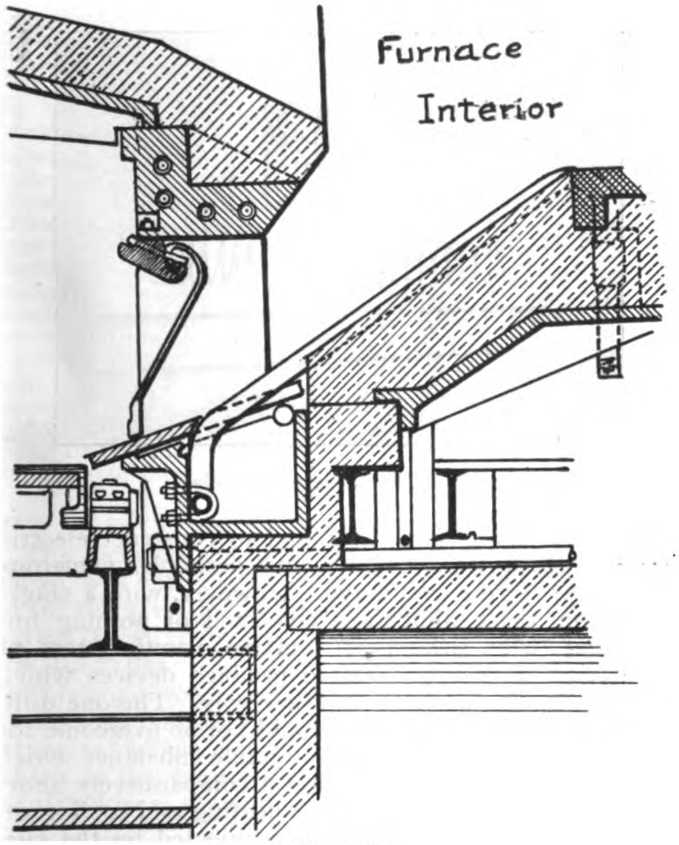

Fig. 170.

The bottom of the door burns off quite rapidly and should, as a result, be made removable. The problem is how to do this without introducing new troubles, see Fig. 168. Any bolts located on the inside of the door at (a), will burn in so tightly that they cannot be removed, and bolts which are located on the outside, for instance at (b), have a short lever arm, unless the ribs are carried out quite far.

Forge furnaces are responsible for another quite troublesome design of doors, namely, the split door. Their use is encouraged by the fact that two small forgings of different size can be heated in one door opening, if a split door is used, see Fig. 169. The split door is troublesome, because the proper guiding of each half is very difficult. The two parts flop around, hang out of square, allow wide openings for flame discharge and the burning out of doors, door frames and furnace fronts. The split door is a nuisance and should be avoided.

A very interesting piece of door design occurs at the delivery end of a continuous heating furnace with gravity discharge, see Fig. 169. This type of door is a compromise. It is located at the hot end of the furnace and should be protected by refractory material. On the other hand, it must withstand the impact of the billets sliding down the inclined skid pipes and it must swing out of the road of the billets. Short sections of cast iron, or better, cast steel, serve the purpose. Admission of cold air is prevented, and excessive heat loss is prevented. Still the loss of heat is quite noticeable, because the doors become dull red hot.

Chain doors serve a similar purpose. They protect the workmen to some extent and are a little better than no door at all. They should be used only in places where a regular furnace door cannot be used.

HEAT TREATMENT OF HIGH SPEED STEEL.

J. L. Thorn, Metallurgist of the U. S. High Speed Steel Tool Co., recently presented a paper on the above subject which has been abstracted as follows:

Realizing the importance of heat treatment, close attention should be given to every detail which will enable the operator to insure reliable results. Both the crucible and the electric furnace high speed steel are good. In a general way, chemical composition should be as follows:

Carbon	.60 to .70
Silicon	.20 to .30
Sulphur	.025 maximum
Phosphorous	.025 maximum
Manganese	.25 to .35
Chromium	3.25 to 4%
Vanadium	.25 to 1%
Tungsten	16.00 to 18.00

The author discusses the davantage or disadvantage of various elements in the steel. He then takes up the various methods of commercial heat treatment. He says heat treating consists essentially of first preheating the tool; second, raising it to the high temperature; third, quenching; and lastly, reheating, drawing or tempering. To accomplish these four operations successfully, the form of the furnace should be carefully considered with relation to the type of tool to be hardened. He takes up in particular the oven type of furnace used for treating milling cutters, blades, forming tools, etc. Mr. Thorn then discusses the purpose of pre-heating and the main points to be considered in doing that work; the object in bringing the piece to a high temperature as quickly as possible, the importance of heating cutting edges evenly and the best means of accomplishing this.

He also discusses the best method of keeping the furnace hearth clean, and suggests using a sheet of asbestos to cover it, renewing this sheet each day.

His experience with nickel pyrometer tubes has been that while they last about twice as long as most of the tubes now on the market at a temperature of 2300 degrees F. the cost scarcely repays the investment.

Electric Heaters for Heat Treating Furnaces

Review of Various Types—Development—Resistor Materials and Their Properties—Resistor Design—Metallic Resistors and Their Application to Furnaces and Quenching Tanks.

By H. O. SWOBODA,
Consulting Electrical and Mechanical Engineer, Pittsburgh, Pa.

PART I.

THERE are two distinct types of electric heaters which can be used in electric furnaces. One type is represented by the electric arc and the other by the electric resistor.

The electric arc is extensively used in furnaces for reducing ores and melting metals; for heat treating purposes, however, its application is limited due to the fact that the heat of the arc cannot be distributed as uniformly as is desirable and that for this reason automatic temperature control is difficult to apply. Besides this, under certain conditions, the gases developed by the arc may have an influence on the furnace charge.

The electric heaters of the resistor type permit an absolute uniform distribution of the heat, and in connection therewith the temperature within the furnace can be controlled very closely, either by hand or automatically. These heaters generate the heat by the so-called "Joulean Effect," changing the electric energy into heat on account of the resistance of the electric circuit, consequently, the higher the resistance of a wire, the more heat per lineal inch will be produced for the same amount of current passing through under otherwise the same conditions. Naturally the application of resistors is limited to processes requiring temperatures not higher than the material of the resistor will stand. While temperatures as high as 5500 degrees F. can be obtained, special designs must be provided, when the required temperatures are in excess of from 1800 to 2000 F. degrees. As most commercial heat treating processes are occomplished with temperatures below the limit just given, it is the intention to mention in this article mostly furnaces for processes with temperatures which do not exceed 2000 F. degrees.

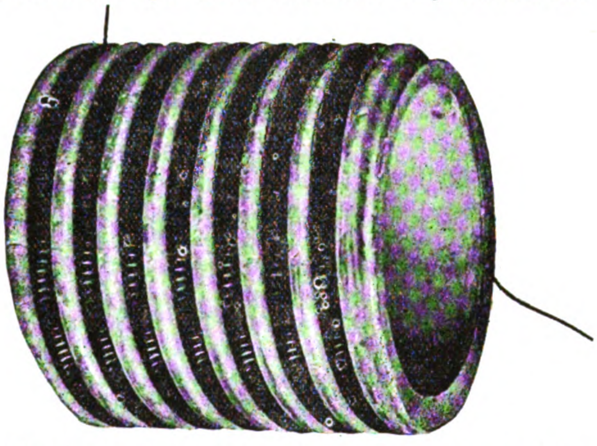

Fig. 2—Resistor coil wound around a grooved tubular muffler.

It can readily be understood that the materials required for electric heaters have to meet a great many different conditions, and due to the high temperatures to which they are subjected, the substances available for said heaters are very limited. In fact, quite a number had first to be developed before satisfactory results could be obtained.

Development of the Art.

About 35 years ago, when the first attempts were made to apply electric heat and to construct electric heaters which were suitable and desirable, numerous difficulties were encountered. However, with a single exception, these difficulties consisted of nothing but the usual "baby sicknesses," and the manufacturers of reputation were soon able to produce devices which could be depended upon in every way. The one difficulty just mentioned, which could not be overcome for a long time, was the lack of a suitable substance which would not be destroyed within a comparatively short time by the continued alternate heating and cooling off to which any electric heater is subjected by the current. In fact, the choice of the designer of 35 years ago was practically limited to two materials for the resistor, i. e., to platinum and to the incandescent lamp.

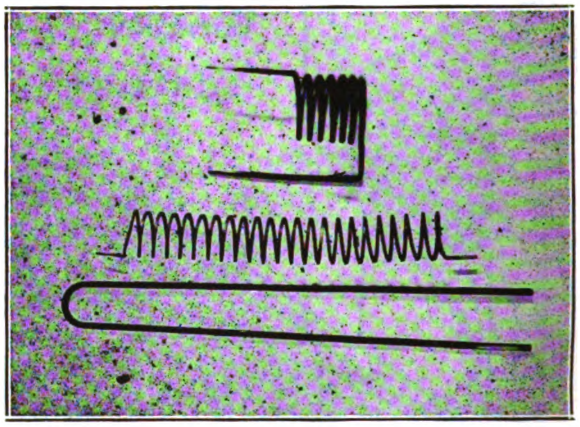

Fig. 3—Rigid resistor coils.

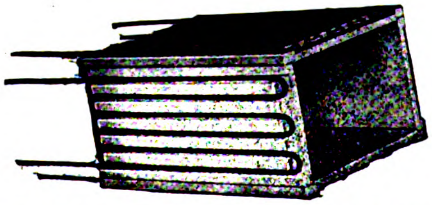

Fig. 4—Muffle plates with rigid resistor wire coils.

The high cost of platinum, of course, made its application impracticable for all commercial purposes except for physicians' and dentists' instruments and per-

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Fig. 1—Table of Resistor Material.

Name of substance	Physical Condition or Composition of Substance	Manufacturer or agent	Resist. in Ohms per Cir. Mil Ft. at 68 degrees F.	Temperature co-efficient of restivity for one degree F.	Specific gravity grams per Cu. Cm.	Approx. Max. working Temp. in open air, degrees F.	Approx. melting point in degrees F.
Copper	Annealed	..	10.4	0.00217	8.89	500	1981
Platinum	Pure	..	57.4	0.00204	21.50	2700	3190
Iron	Annealed wire	..	62.9	0.00280	7.78	750	2700
Iron	Cast, gray	..	380.0	......	7.21	1000	2700
Nickel		..	64.3	0.00400	8.90	1200	2940
Tungsten	Annealed	..	136.2	0.00250	19.10	....	5432
Molybdenum		..	34.3	0.00185	8.60	....	4532
German Silver	18% Copper, Nickel, Zinc	..	200.0	0.000172	8.50	500	1880
German Silver	30% Copper, Nickel, Zinc	..	290.0	0.000111	8.50	500	2120
Advance	Copper Nickel	1	294.0	Nil	8.90	700	2300
Ideal	Copper Nickel	2	300.0	0.00001	8.85	700	2200
Monel	Copper Nickel	3	256.0	0.00198	8.90	1112	2480
Krupp	Nickel Steel	4	511.0	0.00039	8.10	1100	....
Climax	Nickel Steel	1	525.0	0.00040	8.14	1000	2300
Phenix	Nickel Steel	2	520.0	0.00030	8.09	1000	2100
Tico	Nickel Steel	5	517.0	......	....	....	....
No. 193 Alloy	Nickel, Steel, Chromium	1	523.0	0.00040	8.15	1200	....
Comet	Nickel, Steel, Chromium	2	525.0	0.00040	8.15	1200	2750
Nichrome	Nickel Chromium	1	660.0	0.000095	8.15	1800	2700
Nichrome II.	Nickel Chromium	1	660.0	0.000099	8.02	2000	....
Kromore	Nickel Chromium	1	580.0	0.000134	8.90	2100	....
Calido	Nickel Chromium	2	600.0	0.000190	8.15	1800	2800
Rayo	Nickel Chromium	2	575.0	0.000100	8.05	2000	3000
Chromel "C"	Nickel Chromium	6	640.0	0.000100	8.12	....	....
Carbon	Retort	..	4325*	Not constant	1.80	6000†	6700
Graphite	Acheson	..	4875*	Not constant	2.20	6000†	6700
Carbon Filament	Treated	..	6950‡	Not constant	...	3500†	6700
Granular Carbon	Amorphus	..	.....	Not constant	...	6000†	6700
Silit	II	7	.....	Not constant	...	2500	....

*At 5400 degrees F. †Air excluded. ‡At 3500 degrees F.

1. Driver Harris Company. 2. Electrical Alloy Company. 3. Supplee Biddle Hardware Company. 4. Thomas Prosser & Son. 5. American Steel & Wire Co. 6. Hoskins Manufacturing Company. 7. Gebruder Siemens & Co.

haps for a few laboratory devices.

The incandescent lamp, on the other hand, though cheap, was entirely too bulky to be successfully adopted for the great many different possibilities which presented themselves. Nevertheless a limited number are still in use.

This condition of affairs induced the manufacturers to develop substances, which would withstand the strain to which electric resistors are subjected and which at the same time could easily be fitted to and insulated from the equipments, which are to be heated.

Resistor Materials.

The principal materials suitable for electric resistors are listed in the accompanying table, Fig. No. 1, which is a revision of the table published by the writer in the "Electric Journal" during the year 1913.

The metals of the first group, copper, platinum, wrought iron, cast iron, tungsten and molybdenum are used for the resistors in special cases only.

The data on the copper-nickel-zinc (group 2) as well as copper-nickel alloys (group 3) are of historical value only so far as industrial electric heaters are concerned as they were superseded 25 years ago by nickel-steel alloys (group 4) and finally 14 years ago—in 1906—by the nickel-chromium alloys (group 6). These alloys were discovered by M. Marsh of Detroit, Mich., and are thoroughly protected by patents. They can be operated at temperatures as high as from 1800 to 2000 F. degrees without being injuriously affected. Their resistance is about 60 times that of copper.

The nickel-steel-chromium alloys (group 5) are superior to the nickel-steel group and are offered on the market for electric resistors which are not subjected to temperatures higher than 1200 F. degrees, free from royalties which are to be paid on wires of the nickel-chromium group.

A few other substances with similar properties have since been discovered but so far, the nickel chromium alloys have maintained their supremacy. In other words, the foremost technical difficulty, which prevented the general use of electric heat, was successfully removed more than a decade ago. This statement, however, should not be misconstrued and understood to mean that nickel-chromium is suitable for any and all purposes under all conditions. To the contrary, electric heaters have to be carefully calculated for each individual case and, if this is not done, the possibility of the "burning out" of the heater exists the same as before.

While the development of the metallic resistor was going on, carbon, graphite and similar substances were also tried out and it appears that during the last few years resistors made of these materials are used with success.

The principal substances of this class are listed in the last two groups of figure No. 1. Naturally when using carbon or graphite, it has to be realized that these materials oxidize very rapidly at comparatively low temperatures. This objection, however, is not as serious as it may appear at first glance, simply because, whenever carbon or graphite is used it is either enclosed in such a manner that but little air can get in contact with it or in case the air should strike the carbon or graphite resistor, carbon monoxide and carbon dioxide are formed rapidly, retarding the oxidation. Therefore renewals of these resistors need not be made as often as may be anticipated and since carbon and graphite are low priced materials, this upkeep is not more expensive for a careful design than the renewals of the resistors of the metallic type. Silit mentioned in the last group of table Fig. No. 1, is a substance which has not as yet been extensively used in this country. In Germany and Switzerland, however, excellent results have been secured during the last 15 years with these materials and there is every reason to believe that the application of resistors of this type will soon be made in the United States.

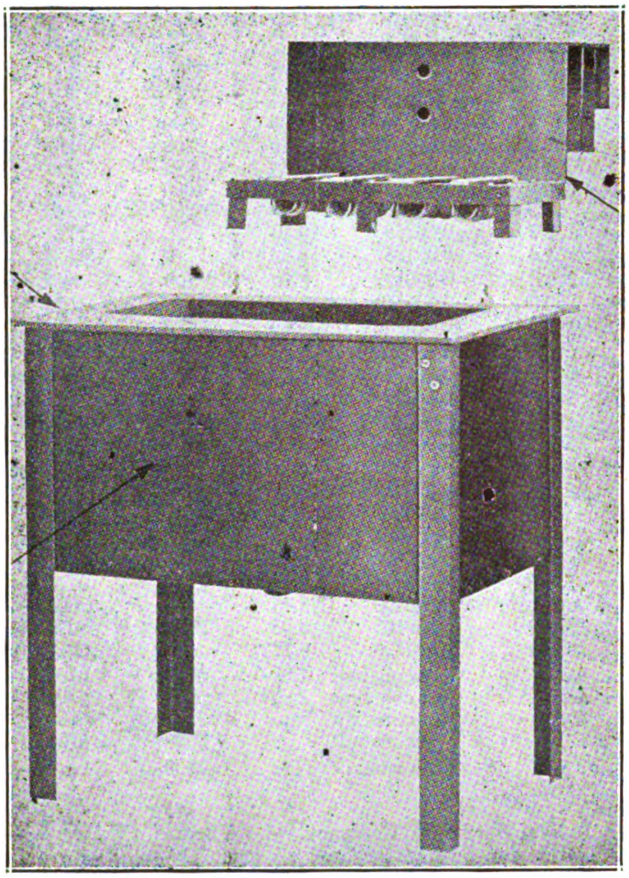


Fig. 5—Oil tempering bath with sheath wire heating units.

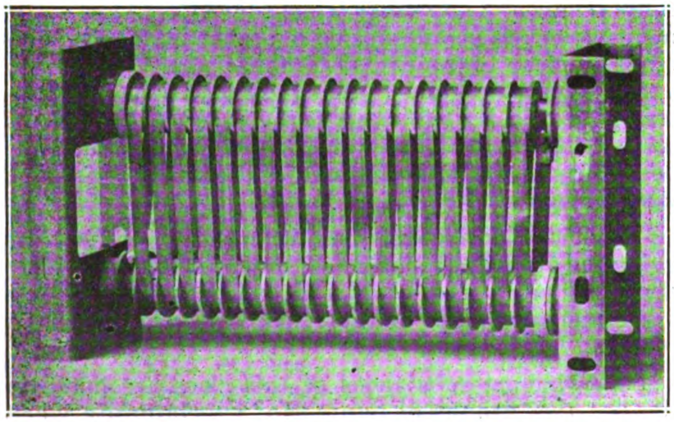


Fig. 6—Ribbon resistor unit for low temperatures.

Resistor Designs.

With fuel furnaces for all different purposes on the market for a great many years, it may appear at first glance that it should be an easy matter to apply the same design for electric furnaces by merely closing the chimney connections, removing the fire grates or gas burners and substituting a sufficient number of electric heater units instead. While this method is possible and may be under certain conditions ever better than any other way, it is safe to assume in most cases that such an arrangement of the electric heaters does not permit the utilization of all the advantages which they offer over fuel heat. As electric heaters can be subdivided and each unit placed closely to the charge which is to be heated, it is far better to discard the practice applied in connection with fuel heat and design electrically heated furnaces on new principles which permit the utilization of the various advantages.

Fig. 7—Steel clad resistor unit for low temperatures.

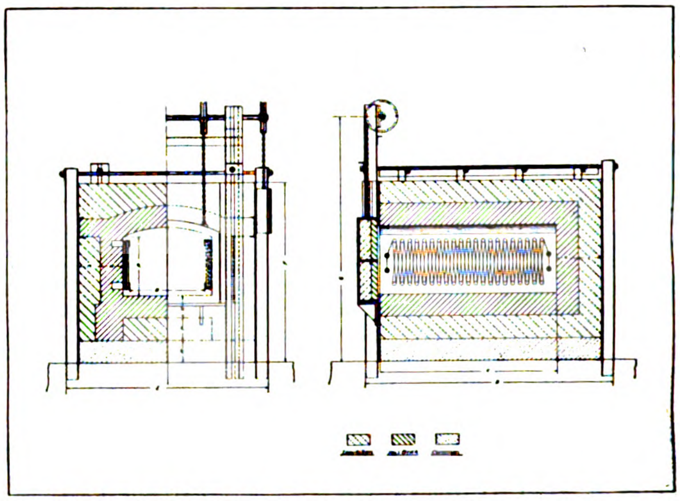


Fig. 8—Ribbon resistor in an annealing furnace.

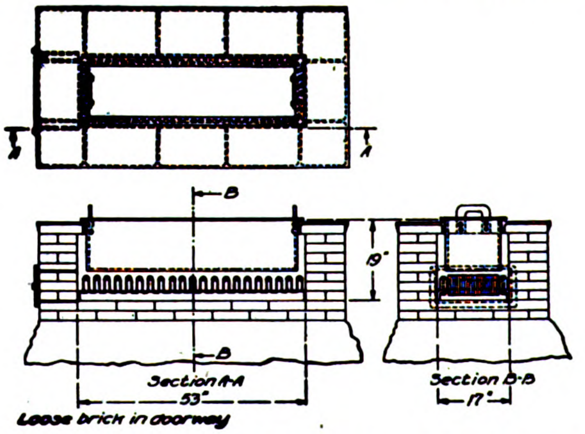


Fig. 9—Ribbon resistor for tanks for soft metals and hardening solutions.

Due to these conditions, electric furnaces for heat treatments cannot be standardized to the same extent as fuel furnaces and a thorough study has to be made in each case in order to obtain the most favorable conditions. In the following, a number of electric heaters and the method of their installation is illustrated and described. On account of the limited space, only electric heaters with metallic resistors are shown in this issue. Heaters with carbon and graphite resistors will be described in part II of this article in a later publication.

Furnaces with Metallic Resistors.

For furnaces requiring only a small amount of electric energy (less than 1 kw) helical coils of round wire can be wound around a fireproof tubing as shown in Fig. 2. This tubing is made of material, which is a thermal conductor and an electric insulator, and which does not crack from the alternate heating and cooling off, to which it is subjected. The ends of the resistor wire should be connected to suitable terminals and the entire coil thoroughly covered with heat insulating material, so that the largest portion of the heat generated has to pass through the tubing walls into the inner space.

If nickel chromium wire is used, temperatures of 1800 F. degrees can be obtained and the resistor coil should have, under these conditions, a life of at least 1,000 hours with a corresponding increased length of life at lower temperatures.

A furnace of this kind may be installed either vertically or horizontally and can be used with advantage for annealing or hardening long thin metal pieces, such as drills, taps, reamers, rods, tubes and small spiral springs.

When furnaces require a larger amount of electric energy than it is advisable to carry in helical coils, as shown in Fig. 2, then rods of larger cross section, either square or round are used in the forms shown in Fig. 3. As resistors of this kind, being rigid cannot be wound around a tubing, they are placed on flat plates as shown in Fig. 4.

These plates are assembled to form the furnace chamber and the number of these plates being not limited, furnace chambers of any capacity can be built. Furnaces of this type 44 inches wide, 10 inches high and 12 feet long have been in continuous and satisfactory operation for many months. The coils as can be seen from the illustration are readily replaced by the operator.

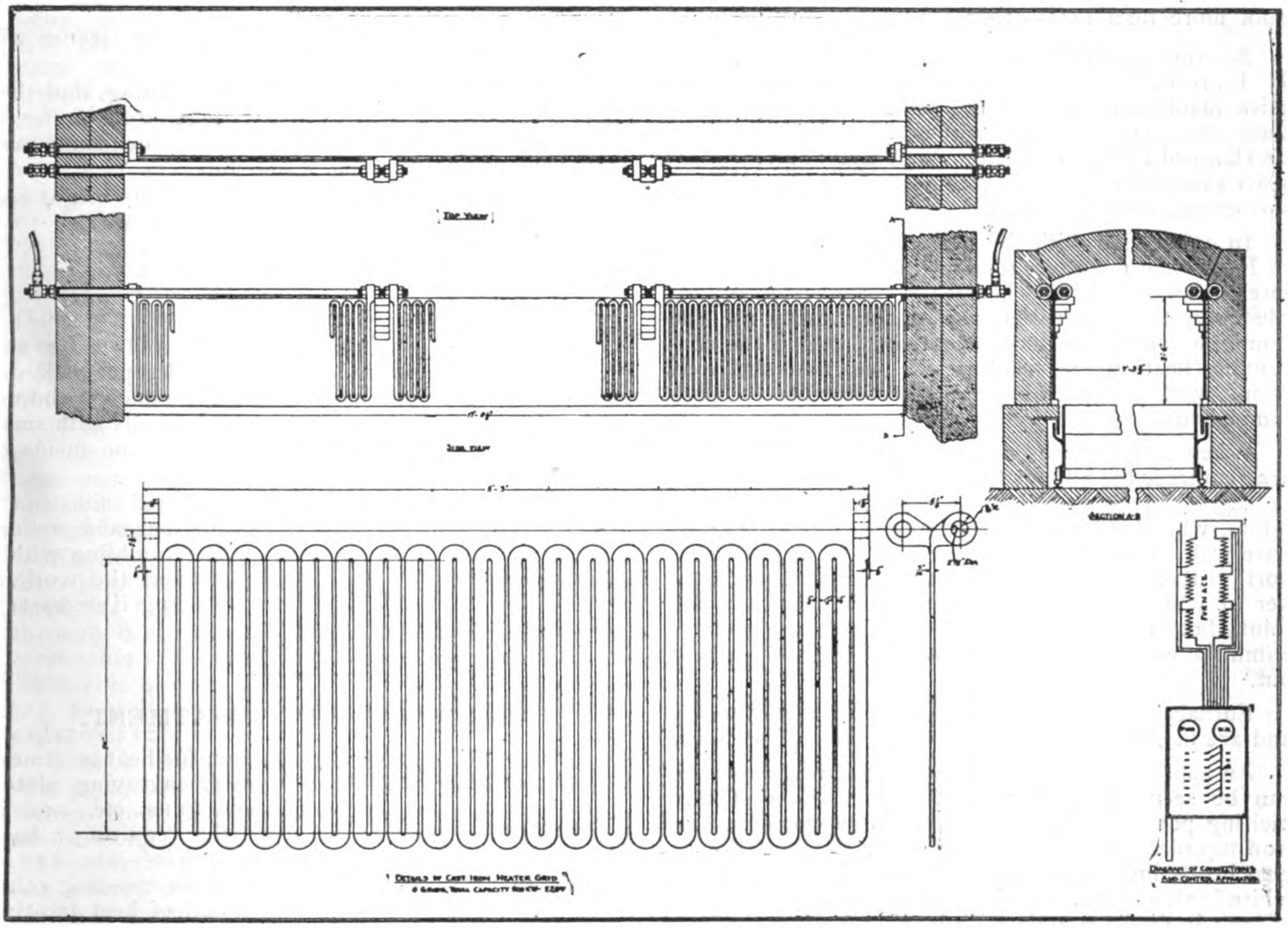

Top View
Side View
Section A-B
Furnace
Details of Cast Iron Heater Grid
Diagram of Connections and Control Apparatus

Fig. 10—Grid resistor for an annealing furnace.

Another type of resistor, shown in Fig. 5 in connection with an oil tempering bath gives excellent results. A bank of these sheath wire units, mounted on a frame, are placed within the tank and the terminals are brought up over the side of the bath under the baffle plate.

Baths of this kind can be made for any capacity. One of the standard sizes has a capacity for treating 1,600 pounds of carbon steel every two hours at 600 degrees F. with a maximum demand of 30 kw.

Whenever large amounts of electric energy have to be used, round or square wires have not sufficient surface to deliver the heat rapidly to the surroundings; in fact, when these wires are operated closely to their permissible maximum working temperature, it may happen, that the core of such wires may liquify and destroy the resistor. This difficulty has been overcome by the use of ribbons only a few thousandths of an inch thick. They are mounted on a number of fireclay bushings assembled on a steel frame and the ends are secured to substantial steel terminals.

Units of this kind, having a capacity of approximately two kilowatts each, are usually mounted in ovens for heat treatment at moderate temperatures (not more than 1,000 degrees F.).

Another type of heater is shown in illustration Fig. 7. Its resistor consists of a slotted ribbon, wrapped in mica insulation and jacketed with sheet steel; these units, the standard capacity of which is 500 watts, can be clamped tightly to bottoms and walls of vessels or placed inside of ovens, the temperatures of which does not exceed 500 degrees F.

In connection with the ribbon resistor unit shown in Fig. 6 it was stated, that it is not used for tempertures in excess of 1,000 degrees F. The reason is, that the connections between the various units are too numerous and liable to become loose, due to the continuous heating and cooling off and that the steel frame work in general is not very suitable for high temperatures.

When temperatures up to 1800 or 2000 degrees F. are required, the ribbon resistor is installed as shown in Fig. 8. It is installed on special refractory insulators, which are built as an integral part of the furnace walls, thus eleminating any form of metallic support. In addition thereto, the ribbon joints, the number of which has been kept at a minimum and the joints between the ribbon and terminals are welded, eliminating all chances of becoming loose and burning out.

Furnaces of this kind are made for any capacity and are in successful operation for a number of years.

An application of the ribbon resistor, just described can be seen in illustration, Fig. 9. The cast iron melting pot or tank, in this case, is supported on an iron top plate, which in turn, rests on a foundation of heat insulating brick. The heaters, operated at almost white heat, are mounted directly beneath the tank, but are not in direct contact with it; they radiate the heat into the bottom of the tank.

In place of ribbon resistors, as described in the two last named cases, cast grid resistors, as shown in Fig. 10 may be used. If cast of nichrome, and if the supporting pipes, which act as conductors, are specially treated, the same temperatures as with ribbon resistors can be obtained with the advantage, that grid resistors are more rugged than ribbon resistors and therefore less subject to repairs and renewals.

Numerous other metallic resistors for electric heaters could be described, but the space does not permit it. In conclusion it merely may be stated that occasionally ordinary iron or steel pipes or iron castings can be used in place of special resistance material, such as nickel chromium or nickel steel.

FINISHING SMALL NICKELED PRODUCTS.

Small size prevents the individual finishing of such small parts as cowl washers, screws, and many other bright metal parts used in the higher grades of automobiles. This leaves the work to be done mechanically, and these suggestions from Chemical and Mechanical Engineering may be found of value.

The process divides itself into four steps, as follows:

(1) Removal of oil by immersing in a hot cleaning solution (200 degrees F.) composed of:

Water	1 gallon
Caustic soda, 76%	3 ounces
Soda ash, 58%	3 ounces
Silicate of soda	1 ounce
Sodium cyanide	½ ounce

Immersion for a few minutes in this cleaner will produce a clean surface.

(2) Wash in cold water after cleaning, and then tumble to remove burrs, etc. Some firms prefer to tumble in pumice stone and water, to which some sawdust, preferably maple, is added.

(3) After tumbling, wash in water and bright acid dip. The bright dip is composed as follows:

Nitric acid, 38%	1 gallon
Sulphuric acid, 66%	1 gallon
Muratic acid	2 ounces
Water	1 pint

(4) After dipping, re-wash in cold water and tumble in warm water to which is added per gallon of water one ounce soap chips and one ounce trisodium phosphate. It is advisable to use steel balls with small spikes, as the points extended burnish the inside of the work.

Some firms prefer to tumble for final finish in a solution consisting of water one gallon, acid sodium phosphate one or two ounces. After tumbling with a light cleaning in a mild alkali cleaner, the work is ready for additional tinning or nickeling if necessary.—From the Melting Pot.

ABOUT CYANIDE TREATMENT.

The use of cyanide of potassium for heat treatment or carbonizing of embossing dies, engraving plates, small steel parts for typewriters, guns, etc., and in general, for a wide range of articles requiring a hard wearing surface without great depth of case, has so many advantages that it is rapidly superseding other methods of shallow carbonizing and of heat treating along certain lines.

Cyanide of potassium is now commercially handled in crystal form.

These crystals are melted in the pot of the furnace, and the molten bath is heated to about 1450 degrees F., at which temperature the best results are obtained.

Small articles to be treated in cyanide are suspended in this molten bath, usually in wire baskets; larger articles are hung from the sides of the pot on wire hooks. It is important that the parts or articles to be treated do not touch the sides or bottom of the pots.

Ordinary cyanide treatment involves leaving the parts immersed in the molten bath from two to thirty minutes.

After the parts have been taken from the cyanide bath they are quenched in oil or water, preferably oil.

Opportunity for America in the Orient

Presenting Ideas and Suggestions, Secured by a Personal Contact With Foreign Countries, Which Are of Interest to Persons Contemplating a Closer Relationship With the Opportunities Offered.

By HERBERT A. ANDRESEN,
President, National Iron & Steel Publishing Co.

IT IS certainly good, after 20 months of globe trotting, meeting nationals of every shade and hue and variety and lack of costume, to be back in foggy, busy Pittsburgh, able to talk and think in American.

Enthusiastic as we may be about America there are many, many things about other countries that we have yet to learn, and which it will well pay us to learn. We don't want Commissions of Chinese, Japanese, Hindoos or Sundanese coming over here to teach us, but it is just as well to remember that everybody in Japan, even to the lowest coolies in the interior, have electric lights, and that they run as wonderful trains between Rangoon and Mandalay in Burma as we do between Pittsburgh and New York, and that even Confucianism in China has some merits as compared with Christianity. So that while we excel every other nation in the use of tooth brushes and in providing for creature comforts, there are many things which we can pick up to our advantage; one of which I think is particularly interesting, viz: How to sell to others than ourselves.

If we are to remain the big factor in world commerce we are at present, when strong competitors will again enter the arena, we have got to get busy and learn how to sell and keep selling to our customers in foreign lands.

England is for the moment our keenest competitor. Borrowing from the example of the Germans there has been some attempt in England to work through organizations; even France, particularly in connection with the newly acquired steel plants in the Thionville basin in Alsace-Lorraine, is doing her selling, as well as considerable of her buying through organized effort.

I am a firm believer that the time was never so ripe as now to effectually plant the American flag in foreign lands. While many of us are in doubt as to the wisdom of interfering with political destinies of other countries, there is no question but that America has entered upon a role that demands some participation in world affairs.

But first of all we must regard extension of foreign commerce as more than a side issue. Irrespective of the wealth of our home market we must definitely plan to go in for world trade as part and parcel of our manufacturing and merchandising program, just as do those other nations to whom world commerce is a vital necessity.

As a primary consideration manufacturers must select representatives abroad of the highest caliber—equal to if not superior to those who represent them at home. Only too often in the past, although I am glad to say there is a constant improvement in this respect, American manufacturers have been represented by men who would not do at home and this naturally has reacted unfavorably to American interests. Although I am an advertising man and believe firmly in the power of the printed word, too great stress cannot be laid upon the value of individual effort as the main link in the sales chain. England sends her finest men into the export field, and I hope the time will come when young men in America will enter into the field of foreign commerce.

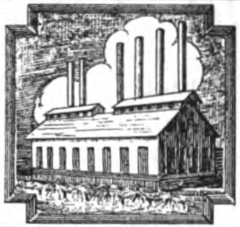
Problems of foreign commerce intelligently attacked are not much more intricate when everything is said and done than the problems of selling here at home. There is no more mystery about selling abroad than there is about the science of advertising. All that is required is intelligent preparation and investigation; and before we know it America will be firmly established as the leading figure in world commerce.

I want to go over the general world situation as I see it briefly. Europe generally, including even England, where exchange renders purchase of American manufactured products prohibitive, is in such a sadly disordered economic, financial and political state that, aside from the prohibitive character of the exchange, it will be some years before we can figure on this as a fertile market for American manufactured products. Foodstuffs, of course, will continue to come in in large quantities, as well as raw and semi-finished products, and to the neutral nations, like Spain, Holland, the Scandanavian countries and Belgium we will be able to sell manufactured products.

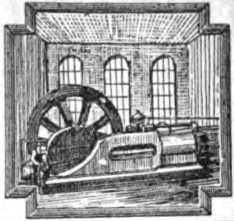
It is to the Orient that I would call particular attention. Backward as it is in many respects, in living conditions, in sanitation, industrially, economically and politically, this wonderful country, peopled by 500,000,000 of the most intelligent and efficient workers to be found anywhere on the globe, already offers a tremendous market for American manufactured products, machinery, particularly cotton spinning and flour mill machinery—steel, hardware and all the staple articles of daily life—a vast continent in itself with a buying power now estimated to be less than $2 per capita as compared with the buying power of an individual inhabitant of the United States, $185 per person, which in itself tells the story. For to increase that buying power by only so much as $1 per capita means to add $500,000,000 to China's import figures. Of this trade we now enjoy only about 13 per cent, while Japan, despite the boycott, supplies over 40 per cent of China's imports.

There is also a wonderful opportunity for Americans in the Dutch East Indies, in the Malay States, in India and in Egypt and even greater opportunities in the Levant, while the markets of Australia and New Zealand are not to be shunned. It is China, however, as a potential field needing development, and Japan which will for some time remain a fairly good market for our products, which hold the center of the stage.

Abstract of an address delivered before the Pittsburgh Advertising Club, August 31, 1920.



STEAM POWER DEPARTMENT



Some Economic Considerations in Design of Power Plants for Steel Mills

Dealing With the Economic Centralization of Power Generation for Various Units of the Steel Industry—How to Design Power Plants for the Greatest Economy.

By T. E. KEATING.

IT is the purpose of this paper to indicate in a general manner some of the important economic considerations that enter into the design of a power plant for a modern steel mill with particular reference to the utilization of blast furnace gas, and the efficiencies and costs that may be expected to prevail in such an installation. It is not intended to discuss matters external to the power plant any more than necessary to determine the fuel supply and power demands. For this purpose certain assumptions have been made.

The plant is to consist of four 500 ton furnaces and mills requiring an average load of 15,000 kw to be maintained twenty hours per day for 310 days per year. Four hours per day of this same period the load will be 9,000 kw, while for the remaining 55 days of the year a load of 6,000 kw will be required to take care of the continuous operation of the blast furnaces, cranes and repair work.

To take care of these load conditions two 10,000 kw units will be required a greater part of the time, and a third is installed as a spare, so that the power generating equipment will consist of three 12,000 kva 10,000 kw 60 cycle 6,600 volt turbine-generator units. With the load demand outlined above, the annual station load factor will then be approximately 40 per cent.

One of the first conditions to be determined is the steam pressure and temperature satisfactory for a plant of the type under consideration. The average steam pressure that has prevailed in the mills using reciprocating engines is about 140 pounds, while in large central stations power companies are satisfactorily using pressures as high as 300 pounds, and three stations operating on 350 pounds.

The trend in steam practice is toward higher pressure rather than extreme superheat. There are two reasons for this; first, a practical consideration that with present-day materials it is more difficult to design equipment to withstand continuous operation on high temperature than on high pressure, and second, a thermodynamic fact that for any definite total temperature of steam the amount of heat available for conversion into work when expanding to a certain vacuum is greater for high pressure and moderate superheat than for lower pressure and correspondingly higher degree of superheat. For example, if a total temperature of 600 degrees F. is desired with 150 pounds pressure, there will be required 234 degrees of superheat and if expanded adiabatically to 28.5 inches of vacuum there will be available for conversion into work 388 Btu. With the same total temperature of 600 degrees and a pressure of 350 pounds only 164 degrees superheat will be required and if expanded through the same range, there will be 426 Btu available for work. To obtain this latter value of 426 Btu with 150 pounds pressure there would be required 386 degrees of superheat which is equivalent to a total temperature of 752 degrees. This means that to obtain the same amount of energy available for work a steam temperature of 752 degrees would have to be obtained and equipment designed to withstand it if 150 pounds pressure were used, while if 350 pounds were used a total temperature of only 600 degrees with equipment to correspond would be required.

Returning to the 600 degree conditions the total heat received from the boiler and feed water heater is 1,259 Btu per pound of steam for 150 pounds pressure and 1,245 Btu for 350 pounds pressure so that the ideal thermal efficiencies are 30.7 per cent and 34.2 per cent respectively. This theoretical gain of approximately 11 per cent cannot be fully realized in the turbine for the reason that such elements of the turbine as work in this higher steam pressure with the resulting decrease in specific volume will have greater leakage and friction losses, so that the economy as expressed in pounds of steam per kilowatt hour is improved only 6 or 7 per cent.

While pressure of 300 pounds and over are becoming standard in large central stations, this figure is probably higher than would be considered today in a plant serving an industry where the generation of power is less.

Abstract of paper read at Association of Iron and Steel Electrical Engineers Convention.

With this final temperature and high efficiency it will be rather difficult to justify economizers. Wrought steel economizers are now being operated satisfactorily, but in order to obtain high efficiency it is desirable to maintain inlet temperatures around 140 to 150 degrees, which requires some method of de-oxidizing the water to prevent tube corrosion. As a preventative of internal corrosion many operators favor economizer water inlet temperatures of about 200 degrees in order to release the entrained air. Any heating in the economizer to bring the water temperature up to 200 degrees cannot be considered in itself as a saving when compared with operation without economizers as this temperature cannot show enough economy to give reason for its existence. It would undoubtedly be argued that the high pressure would require an increased investment for boilers, valves and piping that could be expended to show greater returns in some of the industrial processes. Therefore, a pressure of 250 pounds at the boilers, which will correspond to about 240 pounds at the turbine, will be used. Investigations of the characteristics of materials and present day designs of valves and fittings, confirmed by operating experience, have demonstrated that steam temperatures up to 600 degrees F. can be used satisfactorily. A superheat of 150 degrees F. with 250 pounds pressure corresponds to a total temperature of 557 degrees F. and that figure, which is quite conservative, is used in this problem.

In considering a boiler to operate on blast furnace gas, the results being obtained on units of waste heat type baffled for small area of flow and resulting high gas velocity, are of interest. On units of this type, 24 tubes high and equipped with induced draft fans to produce the desired gas velocity, operating efficiencies of 78 to 80 per cent at 200 per cent rating are obtained with furnace temperatures not exceeding 2,000 degrees. Under these conditions the gases leave the boiler at temperatures in the neighborhood of 460 degrees.

In order to determine finally the economics of economizer installation it would be necessary to make a complete analysis of the investment and operating charges for equivalent stations with and without economizers giving proper consideration to convenience and simplicity of operation. In a station of the size under discussion operating on an industrial system with a load factor of 40 per cent and comparatively low priced fuel, some close figuring will be required to justify economizer installation, and it is not provided in the station under consideration.

While the choice of steam pressure is determined by good engineering practice and experience, and is more or less independent of any local conditions, the choice of vacuum and particularly the type of condenser to be used, is wholly dependent on local conditions. Central stations located on tidewater where a great quantity of relatively cold water is available, can economically purchase and operate turbines and condensers designed for 29 inches of vacuum. Many central stations have base load plants, or certain units in one plant, on which nearly full load rating is carried continuously with equipment designed for high vacuum at maximum capacity. The load fluctuations are then taken care of by other units. However, industrial plants located on rivers with smaller quantities and higher temperatures of water, and usually requiring considerable pumping head cannot justify the size of condenser and amount of pumping power required for this high vacuum. With the turbine operating for the greater part of the time around three-quarter load, it is not necessary or economically desirable to put in a condenser to maintain high vacuum at full load. Therefore, a condenser designed to maintain 28.5 inches of vacuum at 80 per cent load when supplied with 17 degrees circulating water was selected for this problem. This will correspond to 28.2 inches of vacuum at full load. With 80 degrees circulating water this condenser will maintain 28 inches of vacuum at 80 per cent load, while with colder water a correspondingly improved vacuum will be obtained. Inasmuch as the water temperature for nine months of the year will run below 70 degrees, the condenser will operate for the greater part of the time at vacua better than 28.5 inches.

The barometric type of condenser has been used very extensively in the steel mill installations. It has been common practice to pump all the water required to a standpipe, and then lead it to the various condensers, so that no pumps are required in the power house. When the circulating water is contaminated by acid, this character of installation is desirable to avoid pumping the warmer and more corrosive water, as would be necessary with a low level jet condenser. Naturally if there is evidence of an appreciable amount of acid, surface condensers would not be considered. However, the fear of tube corrosion has prevented the installation of surface type condensers in many cases, where proper tube material would have given satisfactory operation. Inasmuch as by modern methods of annealing and drawing, it is possible to produce tubes immune to most of the trouble formerly experienced, and power companies are obtaining most satisfactory results from surface condensers using water previously considered unsatisfactory, industrial plants are giving more consideration to this type in connection with turbines.

The quality and quantity of cooling water, pumping head, cost of treating water, cost of maintenance, as well as initial cost of equipment, all have some bearing on determining the proper type of condenser for a particular installation. A summary of the relative values used for this problem is given in Table 1.

The elevations assumed for determining the pumping heads are based on conditions characteristic of the Pittsburgh district, and are used merely for the purpose of indicating a method of attacking the problem. A similar method will apply for any other conditions assumed. High water level is taken as 30 feet above pool and the ground level as 50 feet above pool. The engine room level is 10 feet above the ground and the basement 20 feet deep, allowing sufficient height for condensers and auxiliaries. In order to make the comparison on an equivalent basis for the various types of condensers, it is assumed that for the jet condenser the water is pumped to a well at the basement level, corresponding to 40 feet above the pool and resulting in 16 feet suction lift for the condenser. The hot well for receiving the discharge water is at the same elevation, i.e., 40 feet above pool. For the barometric and surface condensers the water is pumped from the river through the condensers and the hot wells are at the same elevation as used for the jet condenser. The pumping head for the surface condenser includes tube friction. The power required for discharge pump on the jet condenser is taken care of in computing the fuel costs.

An addition of four feet for pipe friction between pump house and condensers has been allowed in all cases. A deduction of 20 feet from total static head has been made for syphon on the barometric installation and 16 feet on the surface type. These values are conservative and for comparative purposes. In event of surface condenser installation a syphon effect of 20 feet could be secured by proper location of hot well. The surface and jet installations have been assumed as bolted directly to turbine exhaust with exhaust connections sufficient to allow for atmospheric relief and necessary clearances around the foundation. In the case of the barometric type, the cost of excavation for tail pipe and overflow to river, together with the fact that at times of high water it would be impossible to operate except at reduced vacuum prevents installation directly below the turbine. It is therefore necessary to install it with the condenser nozzle about 20 feet above turbine room floor. A loss of .4 inch of vacuum between turbine exhaust and barometric nozzle has been assumed and an equivalent increase in turbine steam consumption is charged against this condenser. When flowing through piping and bends the friction loss of steam at high vacuum is very great. While this figure of .4 inch might be reduced by using decreased velocity, the size of the piping would be increased considerably, and the increased cost might readily offset the gain in economy.

In evaluating the different types a fixed charge of 15 per cent on the respective installations is used, taking into account only the condenser equipment and necessary auxiliaries, assuming that the remaining power equipment and building will be identical for all types. However, in figuring the fuel costs it has been necessary to use the Btu per kilowatt hour for the complete installation, inasmuch as the amount of paper required for circulating, air and condensate pumps varies with each type and if turbine driven auxiliaries are used the different amounts of exhaust steam affect the temperature of feed water and heat required per kilowatt hour. With the surface condenser installation, the requirement at 15,000 kw net station output, charging the station with power required for pumping from the river, auxiliaries for the condenser, excitation, boiler feed pumps and blowers for boilers is 24,100 Btu per kilowatt hour for 93,000,000 kilowatt hours per annum. The corresponding values for the jet and barometric installations are 24,600 Btu and 25,000 Btu respectively. The last two values are based on obtaining water from the condenser discharge wells for treating with a loss of only 8 degrees of temperature. If the condensers discharged back into the river the Btu values would be increased. The overall economy was established at both 9,000 kw and 6,000 kw loads and evaluated for their respective periods and the result is given in Table 1.

It will be seen that the final values for these three types differ from one another by only a small amount, and while the surface condenser is the most economical investment for the conditions assumed, there is not enough in its favor from the dollars and cents point of view to determine positively its selection if any local condition exists which makes its installation undesirable. However, in addition to the considerations tabulated there is another item in favor of the surface condenser, that is, the conservation of heat in the condensate. With a jet or barometric condenser this heat is generally lost in the circulating water discharge, and if charged against either of these installations, would amount to between $5,000 and $6,000 per year. However, in computing the fuel charges for Table 1 it is assumed that with either a jet or barometric, the water for the treating plant is taken from the condenser discharge well and that there is only 8 degrees loss in temperature.

The charge for condenser tube maintenance assumed is much in excess of any data available, but is used so that there may be no indication of favoring the surface type. If comparative data were available, there should properly be some charge against the jet and barometric types for boiler tube maintenance.

Table 1.

Comparative economic costs of various types of condensers operating with 3-10,000 kw turbines, including only such items as vary with the different installations:

Item			
1. Type of condenser	Jet	Barometric	Surface
2. Water required—gallons per minute per unit	12,000	12,000	14,000
3. Pumping head in feet	44	64	56
4. Installation cost of condensers including air and condensate pumps and exhaust connections	$112,000	$78,000	$195,000
5. Pump house including screen and motor driven pumps	135,000	137,000	138,000
6. Water treating plant	65,000	65,000	12,000
7. Total installation cost	312,000	280,000	345,000
8. Fixed charges, 15 per cent	46,800	42,000	51,000
9. Operating charges:			
(A) Water treating plant	17,000	17,000	2,500
Tube maintenance:			
(B) Including regular cleaning and complete retubing of 2 units in 4 years	.....	.....	.....
(C) Pump maintenance	2,000	2,000	2,100
10. Total fixed and operating charges	65,000	61,000	66,400
11. Fuel costs generating 112,000,000 kw hours per annum	360,100	364,800	353,300
12. Total items 10 and 11	425,900	425,800	419,700

Even with water treatment, deposit is carried over into the boilers, limiting the rating and increasing the heat loss due to blowdown.

Inasmuch as there are no local conditions prohibiting the use of a surface condenser and in addition to the financial advantage shown above, the boiler operation will be materially benefitted by its installation, further consideration of the station is based on the use of this type of condenser.

In order to maintain the vacuum specified above each turbine exhausts into a 17,000 square foot condenser circulating 14,000 gallons of water per minute.

In making the study of various condenser applications it was necessary to take different arrangements of auxiliaries so that in each case the exhaust of such steam auxiliaries as were used could be absorbed in the feed water. There are so many possible methods of auxiliary drive and the one selected has so important a bearing on the overall economy of the station, that a study of the methods of obtaining power for auxiliaries might well be the subject of a paper by itself. Therefore only a brief reference will be made here to the various methods and their respective merits.

The determining factors in the choice of method used for driving auxiliaries are reliability of service, and economy, considered from a combined thermal and financial viewpoint. For many years there was a strong prejudice against motor driven auxiliaries, many engineers claiming that there was danger of moisture getting into the windings when installed in the basement around the condenser equipment, and that the heat and dirt in the boiler room would result in excessive maintenance. Inasmuch as in modern stations there is no excuse for steam or water leaks around the condenser nor for excessive dirt or heat in the boiler room, and furthermore, as

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motors are operating successfully in both locations, there can be no question raised regarding the comparative reliability of turbines and motors for this service.

Turning to the thermal economy, steam driven up to the point where the exhaust can be absorbed in the feed water costs about 3,500 Btu per horsepower hour of auxiliary power. However, such auxiliary turbines as exhaust to the atmosphere may require from 35,000 to 100,000 Btu per horsepower hour depending on the economy of the turbine used. Such auxiliary power as is developed by steam that is to be returned to the feed is obtained in the most efficient manner, while such power as is developed by steam exhausting into the atmosphere is obtained in the most extravagant manner. Inasmuch as it is possible to have all auxiliaries driven by individual steam units and be able to utilize the exhaust at all station loads it is necessary to consider other means of obtaining power for the auxiliaries.

Such auxiliaries as are driven by motors off the station bus operate on a Btu cost equal to that of the main generating unit plus the losses in lines, transformers and motors. That is, if the main unit is generating power at a cost of 24,000 Btu per kilowatt hour the cost of auxiliary power is approximately 28,000 Btu per kilowatt hour, or 21,000 Btu per horsepower hour.

Inasmuch as it is desirable to obtain as much auxiliary power as possible by means of steam, some large stations have installed a house turbine-generator operating near or below atmospheric pressure and passing the amount of steam required to obtain the desired feed temperature. Motors on auxiliaries totaling the power output developed by the steam passed are operated from this generating unit and the remaining auxiliaries from the station bus. As a result of the better economy obtained on the larger unit and the greater heat range available due to the exhaust pressure being below atmospheric, this system results in a greater proportion of the auxiliary power being developed by a steam passing to the feed water heater, than in the case of separate smaller steam turbines. This house turbine has the further advantage of being operated on a separate bus so that the motor driven auxiliaries are not affected by line trouble on the main bus.

In addition to the methods of auxiliary drive mentioned above there are other possible arrangements, such as driving all auxiliaries by motors and bleeding steam out of the turbine, or using steam drive and returning the excess exhaust into the low pressure stage of the turbine.

Inasmuch as this station is not large enough to justify economically such features as a house turbine, and it is desired to make the design and operation as simple as possible consistent with good economy and reliability, these refinements for obtaining the highest degree of economy were not considered. The boiler feed pumps and induced draft fans are to be turbine driven and the exciters to be dual drive, that is, a turbine and a motor both connected to the generator, so that in event of failure of motor drive the turbine will pick up the excitation load. All other auxiliaries including circulating, air and condensate pumps, forced draft fans and stoker drive for such times as coal is required, will be driven by motors from the main generator.

While it is desired to limit this paper to a discussion of power problems, the blowing of the furnace is so closely allied that it will have to be included. Turbo blowers have given such satisfactory service, that they undoubtedly would be considered in this plant, and the blowers should be in the same operating room as the generators, and take steam from the same boiler room. Therefore, in calculating the steam consumption of this plant, four 40,000 cu. ft. per minute blowers with four 5,000 square foot condensers are included.

Table 2 gives an estimate of the steam consumption for this station, and is based on 5-1,500 hp boilers operating at 170 per cent of rating. In calculating the boiler feed pump requirement it is assumed that two out of four 500 G.P.M. pumps are operating. While it would be possible to carry this load more economically on one pump of large capacity, it is well to have considerable leeway in capacity of pumps operating on a variable load. The resulting feed temperature of 207 degrees is, of course, subject to variation a few degrees one way or the other, and is probably so high that steam might be lost on swinging load. In order to have this factor under control, it is therefore recommended that instead of putting in a larger pump resulting in less steam consumption and correspondingly lower feed temperature, that with an installation of four pumps, there be two steam driven and two motor driven.

Table 2.

Estimated steam consumption on 15,000 kw load on two units, and four 40,000 C.F.M. blowers with auxiliaries. All auxiliaries motor driven except boiler feed pumps and induced draft fans.

Item	Total steam per hour
1. Net station output, 15,000 kw on turbine generators 2 units	186,000
2. Turbo blowers, 4 units	101,000
3. Circulating pumps serving condensers for generators and blowers	9,700
4. Air and condensate pumps serving condensers for generators and blowers	2,700
5. Excitation	1,300
6. Induced draft fans	30,800
7. Forced draft fans	1,400
8. Lighting and house service pumps	700
9. Total items 1 to 8	333,600
10. Make up-boiler blow, leaks, etc., 8%	27,000
11. Sum of items 9 and 10	360,600
12. Boiler feed pumps	9,000
13. Contingencies	11,000
14. Total demand on boilers	380,600
15. Btu in auxiliary exhaust 40,990 × 1,190 = 48,600,000	
16. Btu in condensate, 311,900 × 55 = 17,130,000	
17. Btu in make up, 27,710 × 38 = 1,055,000	
18. Total items 15 + 16 + 17, 66,785,000 Btu.	
19. Item 18 = 175 degrees. Item 14	
20. 175 degrees + 30 degrees = 207 degrees boiler feed.	

By a computation similar to Table 2, a feed temperature of 210 degrees is obtained at a station load of 9,000 kw if two steam driven feed pumps are operating and at 6,000 kw a temperature of 195 degrees with one steam driven pump.

In order to determine the amount of gas available a coke rate of 2,000 lbs. is assumed resulting in 140,000 cubic feet of gas per ton of coke, and a heat value of 95 Btu per cubic foot. With four 500 ton furnaces operating this is equivalent to 1,110,000,000 Btu per hour. Allowing an availability factor of 80 per cent to take care of loss of gas during tapping, poor gas and irregularities in supply, a value of 888,000,000 Btu is obtained. Allowing 30 per cent for heating stoves, there is available for blowing the furnaces and power purposes 622,000,000

Btu per hour. Four blowers and auxiliaries require 134,000 lbs. steam per hour, which with 76 per cent boiler efficiency and 207 degrees feed, is equivalent to 196,000,000 Btu per hour, or 22 per cent of 888,000,000 Btu. This leaves 426,000,000 Btu per hour available for power generation, which at rate of 24,100 Btu per kilowatt hour is equivalent to 17,700 kw net station output.

Looking at the gas supply from another angle assume that at time of tapping, when gas from only three furnaces is available, there is an availability factor of 90 per cent, and stoves require 30 per cent, leaving 523,000,000 Btu per hour for blowing and power. A power load of 15,000 kw will require 362,000,000 Btu and three blowers under load with the fourth running light, will require 155,000,000 Btu, giving a total of 517,000,000 Btu.

Of course, such an operating condition as an exact balance between gas supply and power demand is a practical impossibility, and it will probably be necessary to burn coal under one boiler a greater part of the time.

For this station, it is suggested that eight 1,500 hp boilers be installed, the average load to be handled by five units at 170 per cent rating, while 20,000 kw load will be carried on six units at the same rating. All boilers would be equipped for burning gas and four for burning coal. It is not intended that the boilers should burn coal and gas simultaneously, but that four boilers would ordinarily burn gas and one burn coal, and enough boilers should be equipped with strokers to carry the load in case of loss of gas.

The station would be located adjacent to the furnaces and the best space distribution with reference to the furnaces would be to have the boilers in a single row, and make the turbine room of same length as the boiler room. With three turbine-generators and five turbo blowers set longitudinally in a turbine room of same length as boiler room, there would be sufficient space between units for withdrawing the fields and handling overhaul work.

In Table 3 is given an approximate estimating cost of an installation such as has been outlined. It is understood that the various items are intended to indicate the relative rather than the absolute costs and may be subject to considerable variation, depending on the location of the plant, and the type of equipment bought and method of installing it. Costs of excavation and foundations may readily differ 100 per cent in various locations. The total figure, which is the most important, represents a fair estimating cost for such a plant under present day conditions.

Out of the total cost of $5,441,000 approximately $3,600,000 is chargeable to the electric power plant. This cost of $120 per kilowatt represents a fair price under present conditions. Some central stations with refinements to obtain the highest economy, machine shops for repairs, and switching for operation on systems of large capacity have run as high as $150 per kw.

Assuming 15 per cent fixed charges on $3,600,000 and 112,000,000 kilowatt hours per year, the kilowatt hour cost for fixed charges is .481 cents, or practically half a cent per kilowatt hour.

Using the fuel charge of $353,300 per annum, as given in Table 1, this is equivalent to .315 cents per kilowatt hour for fuel alone, bases on charging blast furnace gas equivalent to coal at $3.50 per ton. If $5.00 coal is used, this figure for fuel becomes .45c per kw hr. The fuel cost in stations of this type is usually between 75 and 80 per cent of the total operating cost. Using a factor of 75 per cent, the operating costs per kilowatt hour for $3.50 and $5.00 coal are respectively .42c and .6c. Adding these figures to the fixed charges above gives total power costs of .9 and 1.08 cents per kilowatt hour. That is, the fixed charges and operating costs are approximately equal and power may be expected to cost about 1 cent per kilowatt hour when generated in a station of the type outlined.

As stated above, it is not the intent of this paper to show an ideal design of power plant, but rather to indicate some of the economic considerations involved in determining the design of a station for operation in connection with blast furnaces. If this paper leads to serious discussion and thought tending to efficient utilization of available heat and generation of power in steel mill projects, it will have served its purpose.

Table 3.

Estimated cost of power plant for steel mill, including three 10,000 kw turbine generators and five 40,000 cfm turbo blowers:

Item	
1. Excavations and foundations	$ 500,000
2. Building of structural steel and brick	400,000
3. Boilers, 8-1,500 hp including superheaters and brick	650,000
4. Stacks and breeching	100,000
5. Gas cleaners, piping and burners	300,000
6. Stokers, fans shafting and air ducts	120,000
7. Induced and forced draft fans	75,000
8. Coal storage, crane, ash handling	50,000
9. Feed water heaters	15,000
10. Feed and power house service pumps	20,000
11. Water treating plant	12,000
12. Turbine-generators and air washers	640,000
13. Turbo blowers	650,000
14. Condensers for generating and blowing units, including pumps and exhaust connections	300,000
15. Pump house, including screen and pumps	150,000
16. Piping and covering, steam and water	320,000
17. Exciters, motor generator set, switching, house transformers	125,000
18. Gauges, flow meters, laboratory equipment, etc.	25,000
19. Crane	15,000
20. Construction plant equipment	20,000
21. Total	$4,487,000
22. Contingencies, 5 per cent	224,000
23. Total	4,711,000
24. Engineering and supervision, 10 per cent	471,000
25. Total	5,182,000
26. Interest charges on portion of capital required during construction, 5 per cent	259,000
27. Grand total	$5,441,000

NEW MULTI-CENTRIFUGAL GAS CLEANER.

(Continued from Page 551)

Coke dust used in test No. 24, all passed through 200 mesh screen. Test No. 32 was made to correspond to slip conditions in blast furnace. Above tests up to and including No. 27 were all made on 12 inch diameter units, tests No. 28 and up were made on 18 inch diameter units. We consider for commercial installation, considering gas velocity and efficiency, that 8 inch diameter would be the proper size. Power to deposit dust with 8 inch diameter units would be 1½ times the power of 12 inch units and 2¼ times the power of 18 inch diameter units, with the same initial gas velocity.

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Draft-Combustion and Boiler Stacks

Tests Showing the Actual Draft Losses Prevailing From Various Conditions Due to the Kinds of Coal Used—Actual Stack Draft in Relation to the Losses Through the Fuel Bed.

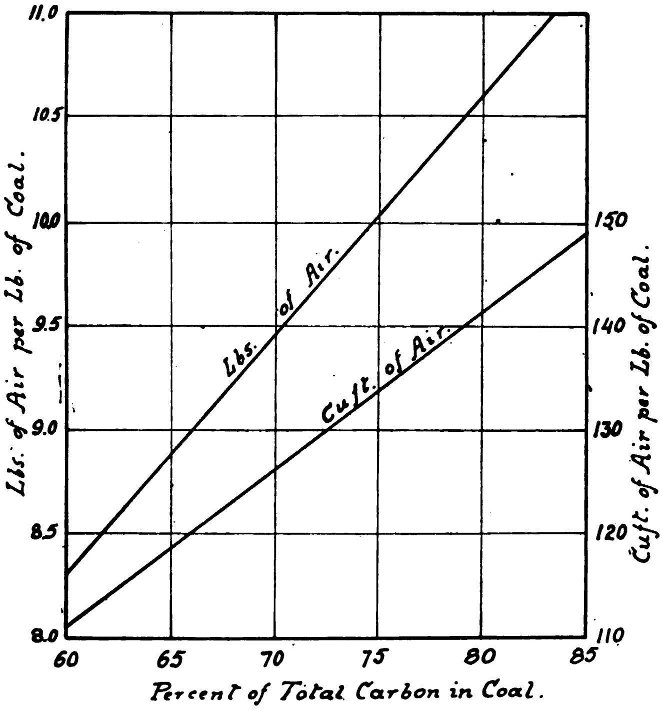
By **F. J. DENK.**

PART I.

DRAFT in a boiler stack, as is well known, is the difference in pressure between the hot gases inside the stack and the cold air outside. This difference in pressure causes the hot gases to rise and force a flow of cold air into the base of the stack. But this cold air, in its passage to the bottom of the stack, passes through the boiler furnace, where it gets heated. It will, therefore, also rise, thus making the action continuous.

The available stack draft must be sufficient to overcome the losses through the fuel bed, the losses through the damper and to give the gases a certain velocity head.

The draft losses through the fuel bed depend upon the amount and kind of fuel to be burnt, i.e., upon the combustion. As there is required a certain quantity of air for the complete combustion of a certain kind of coal, the draft losses through the fuel bed finally depend upon the quantity of air admitted to the furnace.



Air Required per Lb. of Coal for Different Percentages of Total Carbon.

Fig. 1.

It is frequently stated that 12 pounds of air are theoretically required to burn completely one pound of coal. This figure is misleading, as it is too high for many cases. The best way is to calculate the amount required and use the figure thus obtained for further calculations. This can be done without much trouble, as can be seen from the following:

The only combustible constituents in the coal are carbon, hydrogen and sulphur. As part of the hydrogen combines with the oxygen in the coal, to form water, we only have to consider the "available hydrogen," which is represented by the expression $H - \frac{0}{8}$

From any table, giving combustion data, it can be found that we need 2 2/3 pounds of oxygen to burn one pound of carbon, eight pounds of oxygen for one pound of hydrogen and one pound of oxygen for one pound of sulphur. Bringing this in a formula gives:

$$\text{Oxygen required} = 2/3\ C + 8\ (H - \frac{0}{8}) + S$$

Since the ratio, by weight, of nitrogen to oxygen in the air is $\frac{76.85}{23.15} = 3.32$, we have one pound of oxygen in 4.32 pounds of air. The equation, shown above, must, therefore, be multiplied by 4.32, to give the weight of air theoretically required for the complete combustion of one pound of coal. It then reads:

$$\text{Air required} = 11.52\ C + 34.56\ (H - \frac{0}{8}) + 4.32\ S$$

which is for practical purposes, abbreviated to

$$\text{Air required} = 12\ C + 36\ (H - \frac{0}{8}) + S$$

In order to avoid the calculation, the curves in Fig. 1 have been plotted, which give the quantity of air theoretically required in pounds and in cubic feet. For a comparison of the results obtained with the two equations and from the curves we will assume the following composition of the coal:

	Per cent
Carbon	74.79
Hydrogen	4.98
Oxygen	6.42
Nitrogen	1.20
Sulphur	3.24
Moisture	1.55
Ash	7.28

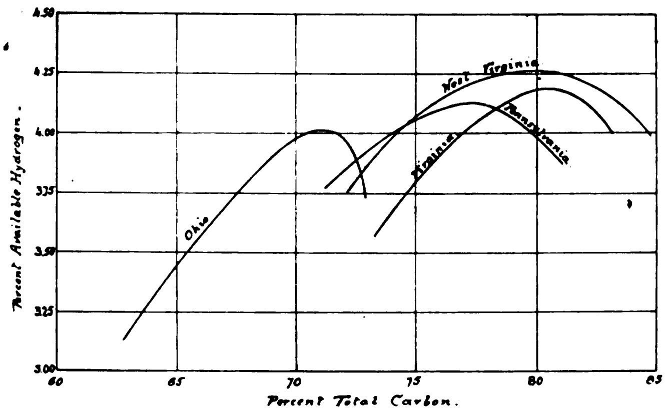
With the exact equation we obtain 10.18 pounds of air per pound of coal; with the approximate equation 10.50 pounds of air and from the curves 10.0 pounds of air per pound of coal. The cubic feet of air required can be obtained from the pound by dividing the latter by .075, the weight of one cubic foot of air at 70 degrees F., which is the assumed boiler room temperature.

A glance at the curve in Fig. 1 will show, that apparently the carbon only is taken care of. This, however, is not the case, because the amount of "available hydrogen" has been considered. This amount has been assumed to be constant and equal to 4 per cnt. That this assumption is not very far from the truth, can be seen from the curves, shown in Fig. 2. The four curves illustrate the relation between available hydrogen and total carbon in the coal from Ohio, Pennsylvania, West Virginia and Virginia. They show an increase in available hydrogen with increasing total carbon up to a certain point, after which the available hydrogen drops again. For the coals from Pennsylvania, West Virginia and Virginia the limits lie approximately between 3.75 per cent and 4.25 per cent, the actual averages being:

	Per cent
Pennsylvania	3.96
West Virginia	4.02
Virginia	3.95

For this reason, the curves in Fig. 1 have been calculated with 4 per cent available hydrogen. For the coal from Ohio, the average amounts to 3.70 per cent. The actual difference for the air corresponding to this percentage and the one above is only one of 1 pound or 1.33 cubic feet. For this reason, the curves can be used for a quick determination of the air required for Ohio coals also as they have been plotted from a total analysis, they are fairly representative and can be used to advantage in place of anyone of the two equations given above.

The amount of air theoretically required is not sufficient to insure complete combustion and an efficient working of the boiler. The composition of the coal as well as its physical structure requires more air for complete combustion than is theoretically necessary. The furnace of a boiler is practically nothing but a gas producer, having a more or less thick bed of incandescent fuel, depending on the kind of coal and on the rate of steam generation. But while in the gas producer the gases generated are to be used some place else, they are, in a boiler furnace, to be consumed immediately in order to furnish the heat for the boiler proper. The composition of these gases during the first three minutes after firing can be seen from the curves in Fig. 3 which are plotted from data obtained by the Bureau of Miners by a test made with Collinsville, Ill., nut coal.

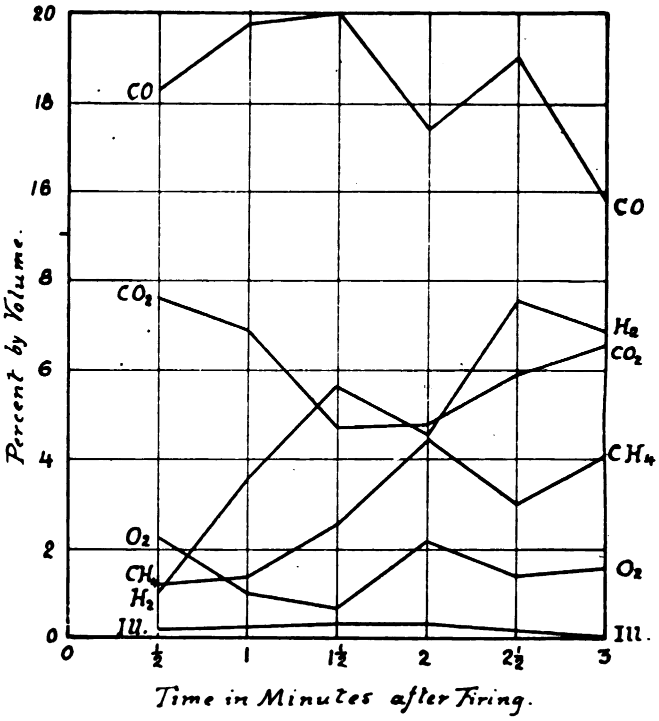


Curves showing Relation between Total Carbon and Available Hydrogen in Coal.

Fig. 2.

These curves show, that hydrogen and methane are low right after firing, amounting to approximately 1 per cent in each case. They increase gradually to 7 per cent for the hydrogen and 4 per cent for the methane, while the illuminants are low and stay low until they disappear at the end of three minutes. The carbon dioxide is comparatively low, whereas the carbon dioxide is high during the entire period, thus proving the statement made before, that a boiler furnace can be considered as a gas producer. For the consumption of these combustible gases a certain quantity of excess air is required, to insure complete mixture and, thus, produce complete combustion.

But, on the other hand, excess air influences the efficiency of the boiler, as heat is required to raise the temperature of this air from that prevailing in the boiler room to that in the furnace. The heat is, of course, lost for the generation of steam. It should, therefore, be the aim of the boiler operator, to keep his excess air as low as possible. An excess of from 40 to 50 per cent is all that is required, whereas an air excess amounting to 100 or even 200 per cent is a dead waste. In how far such an excess influences the amount of coal burnt unnecessarily, can be seen from the curves Figs. 3 and 4 on page 344 of the June issue of this magazine. Fig. 3 shows the relation between excess air and per cent CO_2 in the flue gases, while Fig. 4 illustrates the inter-dependence between per cent CO_2 and per cent preventable fuel loss. Combining the two, we see that with 40 per cent excess air the CO_2 contents in the fuel gases is 14 per cent, the preventable fuel loss being zero, as we need 40 per cent excess air for complete combustion. For 100 per cent excess air we have 10 per cent CO_2 corresponding to a preventable fuel loss of 5 per cent, but for 200 per cent this loss is increased to 10 per cent. This does not seem very much but it will amount to something when applied to the yearly coal bill.

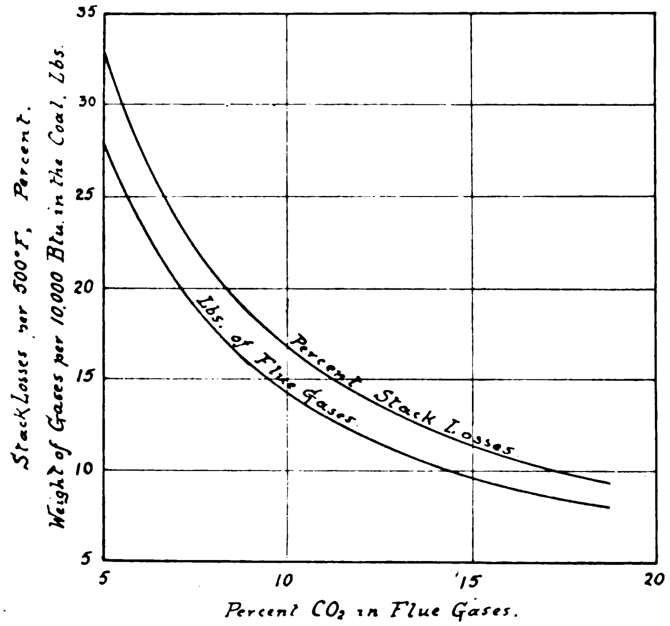


Curves showing Relation between Time after Firing and Composition of the Furnace Gases.

Fig. 3.

The boiler operator can check his quantity of excess air, when he watches the amount of CO_2 in the flue gases. In order to enable him to do so CO_2 recorders should be installed in the boiler room, which show him at a glance the amount of CO_2 in the flue gases. The higher the CO_2, the better the combustion, but this statement does not hold good throughout the whole range. The maximum amount of CO_2 obtainable from good bituminous coal, is about 18.5 per cent. Theoretically there should be obtainable close to 21 per cent, corresponding to the volume per cent of oxygen in the air. But under actual conditions, the coal containing other constituents besides carbon, the maximum percentage is, as was said, 18.5 per cent. It is safe to say, however, that with 18.5 per cent or even less than that, we will have CO in the gas indicating incomplete combustion. This CO can be considered as the remains of the CO generated right after firing, which had not been consumed on account of the incomplete mixture of furnace gases and air, due to an actual deficiency of air below the required excess. Of course, there may be CO in the flue gases even with 14 per cent CO_2 or below, but this can be easily avoided by a careful observation of the conditions in the furnace. But CO with more than 14 per cent CO_2 is an evil, practically unavoidable, except by artificial means, the application and operation of which may cost more than the small amount of fuel loss caused by it.

An objection, made many times, is, that an increase in CO_2 will increase the stack temperature and, therefore, the stack losses. The first part of this objection is right, whereas the second part is wrong. An increase in CO_2 indicates a decrease in excess air, thus approaching best possible furnace conditions, accompanied by an increase in the flame temperature. This higher flame temperature is, of course, followed by a somewhat higher stack temperature. But, an increase in CO_2 meaning a decrease in the amount of air, entering the combustion chamber, means a decrease in the amount of flue gases; and since the rate of decrease in the weight of the flue gases is quicker than the rate of increase of the stack temperature, the result is a decrease in the total percentage of the stack losses. This condition can be seen from the curves, given in Fig. 4. They show the relation between the percentage of CO_2 in the flue gases, the weight of the flue gases, and the corresponding stack losses per 500 degrees F.



Curves showing Relation between Percent CO_2, Weight of Flue Gases and Stack Losses.

Fig. 4.

It is evident, that, since the draft losses through the fuel bed depend, as was stated at the beginning of this article, upon the quantity of air admitted into the furnace through the fuel bed, this quantity of air has to be regulated in order to secure good results. But the quantity of air is variable not only according to the rate of combustion but also according to the kind of fuel to be used. The draft loss through the fuel bed is, therefore, indirectly depending upon the kind of fuel used. The other items, which may influence the draft loss, viz.: depth of the fire bed, and the method of firing, can be disregarded, as they are taken care of and included in the other conditions.

The draft loss through the fuel bed cannot be calculated. We can determine the amount of coal required to develop a certain boiler horsepower, we can also determine the quantity of air required to burn this amount of air efficiently, we can, furthermore, regulate the thickness of the fire to suit prevailing conditions, and we know that the draft losses through the grate depend entirely upon these conditions, but we have no means to calculate beforehand, what this loss will amount to. We only know from actual tests that the draft losses for a certain type of coal or a certain grade of coal, spread on a grate with a certain thickness, will be equivalent to a certain number of inches of water column.

Curves and tables illustrating these conditions and giving the amount of inches of water column, corresponding to the draft losses through the fire bed, can be found in nearly all the publications on boilers, combustion or steam generation. They give an approximate idea of what can happen, but there are no indications of what must happen in the firebed of a boiler furnace. They may, therefore, be used in a general way for approximate determination but they should not be used indiscriminately for the determination of actual condition. Tests should be made, which, then, will reveal the actual draft losses prevailing at actual operating conditions for the kind of coal used.

(To be continued)

A CHART OF ROLLING MILL PRACTICE.

A remarkable chart, entitled "American Rolling Mill Practice," has been worked out and copyrighted by Charles E. Lehr, chief engineer, and W. J. Phillips, chief draftsman, of the Bethlehem Steel Company. The chart, beginning with two sizes of ingots, traces the reduction of the ingot to billets and thence the further rolling to finished products. The feature of the chart, which covers 32 different rolled shapes, is that besides indicating the shape of each succeeding cross section of the rolled product, the area and therefore the reduction from the preceding pass and the elongation are enumerated. These sectional diagrams naturally indicate what are the profiles of the rolls. The finished sections include a rim section, window sash, turbine blade, 100-lb. rail, sheet piling and various common structural and bar sections. Incidental are some illustrations showing the main apparatus, such as the equipment used in a rolling mill and typical layouts of the general types of rolling mill. The chart is 23¼x41¼ in., and may be obtained at $2 from Mr. Phillips.

Editor's Note—In an article on heat furnaces and annealing furnaces appearing on Page 411 of our July issue a statement was made that the price of nickel alloys is about twenty times as high as that of steel. Driver-Harris Company has taken exception to this statement. They have written us a letter in which they give the price of cast nichrome at $1.25 a pound and state that it is being used in castings weighing as much as 4,000 pounds.

INDUSTRIAL RELATIONS

"COMBUSTION, FUELS AND FURNACES, IN RELATION TO SAFETY."

Abstract of address delivered by E. P. Roberts, May 28, 1920, at Chatham Hotel, Pittsburgh, before Western Pennsylvania Division, National Safety Council.

In order to obtain efficiency of combustion, it is necessary to supply the required amount of air and no more. This might seen to be a simple matter but in practice it is far from being so.

Fuels.

The fuels available in this general section of the country are natural gas, oil, semi-bituminous coal and bituminous coal. The principal fuel is bituminous coal, which is usually fed to the furnace in pieces of considerable size but is also fed as exceedingly fine powder, and in my opinion, the use of powdered coal will greatly increase in the near future.

Furnaces.

A furnace is a structure, or chamber, designed for the combustion of fuel. The combustion of the fuel and the utilization of the heat from such fuel for such combustion are independent processes but as for most purposes, such as boilers, the two processes are conducted in the same general structure, therefore, the design of the furnace is interrelated with the design of that portion of the structure which is to utilize the heat.

Let us briefly consider what takes place when bituminous coal is fed into a furnace. Momentarily there is a chilling action but in a very few seconds the volatile matter, which may be 30 per cent to 40 per cent of the weight of the coal, is distilled. At this time a certain amount of air is passing up through the grates and through the body of incandescent coal, the fuel of which is fixed carbon, and some of the gas passing from such incandescent fuel may be CO_2, the combustion being complete, and a considerable portion of it will be CO, which requires another atom of oxygen to obtain maximum heat. Although theoretically, approximately 12 pounds of air is sufficient to supply oxygen for one pound of carbon, nevertheless in actual operation, 18 pounds is good practice and far more is quite frequent.

For the burning of the volatile or distilled gases, about 15 pounds of air is required per pound of volatile. To supply such air in such manner that in about one second (sometimes a little more and sometimes less) it becomes so intimately mixed with the gaseous products arising from the fuel body that each atom of crabon will have a chance to reach out and pick up two atoms of oxygen, and in order to do this, it must dodge 8 atoms of nitrogen, and to have this take place before striking the boiler surface is what makes efficient and smokeless combustion a real problem.

The principal factors are:

1. The coal to be fed at uniform rate so as not to have it momentarily excessive productive of volatile gases.
2. Provide ample flame travel, i. e., distance from the fuel bed to the boiler surface.
3. Provide large capacity, cubic feet, in the combustion chamber so that the velocity will be comparatively low.
4. Avoid stratification of the air and volatile gases by a design which will cause the gases from different parts of the fuel bed to mix.

Stokers are intended to provide uniform feeding of the fuel and in any case, the fuel should be broken into small lumps before being fed, whether by stokers or by hand. Adequate draft is required both as to instensive draft and capacity, and in many cases, stack height and stack area are insufficient, especially when starting fresh fires, the stack temperature being low; and also, the connections between the boiler and the stack are frequently inadequate and materially reduce the draft, returning the food and fuel analogy.

No design is fool-proof and also this is true of the human body which was designed by the Almighty, but many furnaces have such crazy designs considering the character of fuel and the character of load, that we might suppose they were designed by the late "self-called" Almighty.

Smoke.

The smoke nuisance is closely related to fuel efficiency. Excessive smoke indicates that the best efficiency is not being obtained, but at the same time a stack which is perfectly clear all the time indicates the probability of low efficiency. The combustion may be complete but a large amount of excess air is being heated instead of the heat being applied to the purpose intended.

In almost all cases, reduction of smoke results in increased efficiency due to the fact that greater attention is paid to the design of the furnace, to its proper maintenance and to its skillful operation.

I will dwell for a minute or two on smoke abatement from the standpoint of conservation, and safety engineering includes conservation of human health and strength. Before deciding whether or not this subject is worth considering, we should have some idea as to its importance, and from the standpoint of money, the importance of smoke abatement is seldom appreciated, though it has been frequently stated. As stated before, smoke abatement practically always results in fuel conservation, usually not less than 10 per cent and frequently 20 or 30 per cent. In addition, smoke is injurious to health and therefore the working capacity of everyone living in a community where bituminous coal is the principal fuel, is reduced, and doctors' and hospital bills are increased. This applies not only to the worker but also to the children and the not yet born. Some is injurious to plant life. This is a well known fact and we cannot evaluate the decreased beauty of the city, nevertheless, anything which tends to lessen the pleasure of life also tends to increase grouchiness and physical condition, and there is an old saying "Living depends upon the liver." To have maximum production we must have maximum health.

Relative to the economic waste, there have been numerous reports. The report made by the Chamber of Commerce Committee of Cleveland in 1911, of which committee I was chairman, stated that the maximum loss in Cleveland was not less than $12 per capita and not unlikely twice that amount. At that time the population of Cleveland was approximately 500,000. The Mellon Institute, in Bulletin No. 5, printed in 1913, states a damage in Pittsburgh of approximately $10,000,000, based on the cost to the individual, the cost to the household, the cost to the wholesale and retail stores and to public buildings. Ascertaining the damage per ton of bituminous coal used, the Cleveland report shows $1.50 per ton and the Pittsburgh report $1.25 per ton,

(Continued on Page 580)

FOREIGN RELATIONS

THE GERMAN BLAST FURNACE AND STEEL WORKS.

By Hubert Hermanns.

The peace treaty of Versailles has aggravated the difficulties of the German iron works to an enormous extent. The producing capacity of the German works as regards iron and steel has decreased very considerably due to the loss of the iron or emines and the iron works in Lorraine and Luxemburg that were based on this supply. Today the position is this, that the German works depend, in the main, on foreign ore, more particularly on that of Swedish origin. The demand for products made from iron and steel is so large that a fraction only can be satisfied. But there are other difficulties. Owing to the underfeeding of the workmen their efficiency since war broke out has steadily decreased. At the same time, however, the number of workmen has had to be very considerably increased in consequence of the introduction, by law, of the 8-hour day. Wages have had to be very appreciably increased as well, in spite of the reduced hours. While in 1914 the price of labor amounted to, on the average, about 6 marks for the 10-hour day, at present it has jumped up to roughly 30 marks for the 8-hour day. The demands of the workmen for increased wages had to be acceded to as a result of the decreasing value of the German currency and the rising prices for food and articles of daily use. But even with these increased wages the workmen are unable to live in the style which they had adopted in pre-war days. The price of rye bread rose from an average of 28.9 pfennig in 1913 to 2.35 marks in June 1920. One keg of potatoes rose from 7 pfennig to 80 pfennig; one keg of butter from 2.40 marks to 50 marks; sugar from 44 pfennig to 7 marks; beef from 1.73 marks to 24 marks; milk from 24 pfennig to 2 marks.

The production of pig iron amounted to 671,000 tons in April as compared with 699,000 tons in March. Table 1 gives the development of the pig iron and steel production from July 1919 to April 1920:

Table I.

	Year.	Tons pig iron.	Tons steel
July	1919	641,000	618,000
August	1919	521,000	474,000
September	1919	581,000	718,000
Ocotber	1919	445,000	433,000
November	1919	624,000	695,000
December	1919	632,000	692,000
January	1920	665,000	754,000
February	1920	645,000	798,000
March	1920	699,000	840,000
April	1920	671,000	793,000

These figures disclose the remarkable fact that the production of steel is considerably larger than that of pig iron. It is explained from the large quantity of iron scrap that is being worked. If compared with the pre-war figures the production of pig iron is comparatively insignificant. In 1913 Germany produced about 19 million tons pig iron. In 1914 this figure would have been surpassed if the war had not intervened.

The prices for pig iron have been reduced, for the months of June and July. From table II ruling prices in June, July and May may be compared:

Table II.

	June-July Marks per ton.	May Marks per ton.
Haematite	2150.50	2350.50
Iron for steel making, containing little copper	2140.00	2340.00
Pig iron for foundries, I	1740.50	1790.50
Pig iron for foundries, III	1739.50	1789.50
Siegerland iron for steel making	1626.00	1626.00
Spiegel iron	1708.00	1708.00

The prices of iron ore amounted in June to 277.90 marks per ton for crude spar and to 416.50 marks per ton for rust spar. As compared with May the prices for ore have not been reduced. However, the basic prices for steel products have been reduced as follows:

Billets	from 2650 to 2435 marks per ton.
Rolled billets	from 2900 to 2655 marks per ton.
Bars	from 3125 to 2725 marks per ton.
Fashioned bar iron	from 3600 to 3105 marks per ton.
Hopo iron	from 4050 to 3585 marks per ton.
Rolled wire	from 4150 to 3585 marks per ton.
Boiler plate	from 4750 to 4040 marks per ton.
Sheet over 1 mm	from 5600 to 4840 marks per ton.

Technical improvements or extensions of plant of any great importance have not been effected of late in the works although the latter partly want repairing owing to the arduous work carried out during the war. The cost of such repair work is extraordinarily high and this fact coupled with the necessity to keep up production prevented so far any repair work being done. However, the works now try to reduce their working expenses and to strengthen their position as regards the demands of labor by forming combines. An instance is the Gelsenkirchen Bergwerks-Aktiengesellschaft which formerly owned large metallurgical works and ore mines in Lorraine and Luxemburg and which has recently amalgamated with the Deutsch-Luxemburgische Bergwerks-und Huttengesellschaft. The Gebrueder Stumm G. m. b. H. whose principal works are located in the Staar district i. e., under French supremacy have secured a deciding interest in some Siegerland ore mines. On the other hand the tendency of the large mining concerns became apparent, viz: to get hold of medium iron works of the refining industry by buying shares or in some other way. More than ever before the works adopt the policy to carry through the complete refining process of their products in order to compensate in this way the high price of foreign ore.

William C. Rice, special representative of the Pittsburgh Iron & Steel Foundries Co., Pittsburgh, effective September 1, retired from that position to become vice president and sales manager of the Duquesne Steel Products Co., 609 Oliver Building, Pittsburgh.

V V

R. M. Wallace has resigned his position with the Republic Iron & Steel Co., at Youngstown, Ohio, to engage in business. He was previously employed by the American Sheet & Tin Plate Co., at Pittsburgh.

PRODUCTION TOPICS

INCREASED BLAST FURNACE CAPACITY IN OPERATION.

Of the 46 blast furnaces in the Mahoning and Shenango Valleys, 34 are active and pig iron production is averaging somewhat better than two-thirds of capacity. Some of the idle stacks are down for repairs and others on account of the coke shortage. The latest stack to go in blast is Tod furnace of the Brier Hill Steel Co., which was idle for repairs for several weeks. In the Mahoning Valley, only four of the 25 furnaces are down, two at the Ohio Works of the Carnegie Steel Co. and the Niles stack of the same interest, and the Girard furnace of the A. M. Byers Co., Pittsburgh, suspended on acount of a strike of bottom fillers, and now being repaired. The Republic Iron & Steel Co. and Youngstown Sheet & Tube Co. are each operating six furnaces, the Carnegie Steel Co. four at the Ohio Works, the Brier Hill Steel Co. three at the Brier Hill Works, the Sharon Steel Hoop Co. one at the Lowellville and the Struthers Furnace Co., Cleveland, a merchant stack at Struthers, Mahoning County.

Of the 18 furnaces in the Shenango Valley, seven are inactive, two on account of repairs, three because of lack of coke and two of the Republic Iron & Steel Co., one at New Castle, Pa., and the other at Sharon, Pa., on account of business conditions. At New Castle and Sharon, the Carnegie Steel Co.. has five of its eight furnaces in commission, three being idle because of lack of coke. The three furnaces of the Shenango Furnace Co. and the Claire Furnace Co. The Sharpsville, Pa., stack is idle for repairs, as is one of the stacks of the West Middlesex Furnace Co.

At Leetonia, Ohio, McKeefrey & Co. have one furnace out for repairs and the other in blast, while the furnace of the United Iron & Steel Co. is in full blast.

Ore outlook for all the furnace interests is better and it is predicted by operating managers stocks will be sufficiently replenished by the end of the season to insure activity during the cold months.—From Iron Age.

HUGE TRAFFIC IS PROMISED FOR NEW CANAL.

An aggregate traffic of between 25,000,000 and 30,000,000 tons a year was promised for the Lake Erie & Ohio river canal at a meeting at Pittsburgh last week of the joint committee of the chamber of commerce and the Lake Erie and Ohio river canal board in charge of the proposition for a hearing on the canal to be held by the United States board of engineers, Sept. 20. Promise also was given on the construction of proper loading and unloading facilities by private industries and communities of the canal district were read. The replies detailed the use already made of the existing waterways and the traffic that would be sent through the canal.

W. C. Reitz, chairman of the committee, announced he had appointed William H. Stevenson, president of the canal board, to present the case for the committee to the board of engineers. It was also announced that the board of engineers had accepted an invitation to remain until Sept. 21 to take a trip of inspection of the three rivers by boat in order to view improvements made by industries along the banks.

COMBUSTION, FUEL AND FURNACES IN RELATION TO SAFETY.

(Continued from Page 578)

you all know that all the items used in making such estimates, such as painting, houses, etc., have been doubled or trebled in cost. It is probably ultra-conservative to state that the damage per ton of bituminous coal in a city have a fair degree of smoke abatement, is not less than $1.00 and not unlikely materially more, and that the per capita loss is not less than $7 or $8 per year and not unlikely two or three times as much. Considering all these things, is it not worth while from the standpoint of the maker of smoke, and also from the standpoint of the unwilling consumer, to use every effort to obtain increased efficiency by the use of fuel and the lessening of the smoke nuisance.

In conclusion, how may we obtain this result? As citizens of the community, we can work individually but we can do better work by joining such association as is especially competent to give publicity as to the importance of smoke abatement and fuel conservation, and to assist in providing adequate funds and who will follow up the work of the City Smoke Department. In this connection I suggest that each organization interested in civic improvement have a Smoke Committee and that such committee give special attention to such phases of the work as they are most competent to understand and as to which they can be most helpful. The Engineering Society could keep the matter before the engineers and be able to state whether or not the smoke department is well informed, is reasonable, and is doing its duty. In this connection it might be noted that technical men in public employ are frequently damned by those who are not competent to understand the problem and are seldom praised, and if they are, the same is true that the persons giving such praise are not competent to consider the problem on which they have passed judgment. The competent technical man desires not only to have a living wage, but, in some respects, even more important, he desires professional recognition and in most cases such men have no incentive from the professional standpoint. Other phases of the work can be taken care of by other organizations, including providing money, publicity, etc., and the varoius committees, or at least their chairman, can have three or four joint meetings annually, and give publicity to their findings. In some cities, and I believe in Pittsburgh, good results have been obtained, but the best will not be obtained without sufficient money, competent men, a "follow up" system, and giving piblicity to the results, whether same are bad or good. A few cities have, considering the money appropriated, well conducted Smoke Departments, while those of others might be considered, if it were not for the seriousness and importance of the problem, as jokes. Fortunately, your city has stayed in the former class.

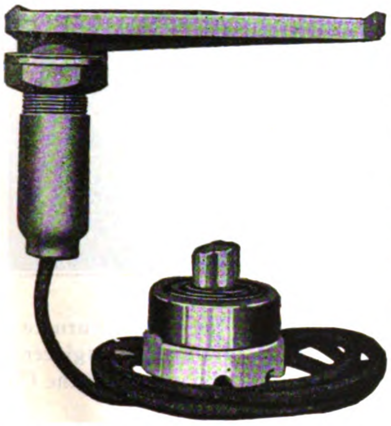
I greatly appreciate the opportunity you have given me, and to the best of my ability, will answer any questions.

The proposal of the directors of the Elyria Iron & Steel Co., Cleveland, to increase the common stock from $1,000,000 to $3,000,000 and to reduce the par value from $100 to $25 has been approved by the stockholders.

WITH THE EQUIPMENT MANUFACTURERS

NEW IMMERSION HEATER HAS ELEMENTS PROTECTED BY BRASS CASTING.

A new immersion type water heater, shown in the illustration, consists of nickel chromium heating elements encased in a flat brass casting which protects them from mechanical injury. The casting is about 3"x6"x½" in size, and makes a simple and durable heater from which is easily cleaned any sediment that may be deposited from the water. When protected in this manner the life of the heating elements is increased, requiring less frequent renewals than with the ordinary immersion type heater, so the manufacturer states. This heater is with sterilizers, glue pots, paste kettles, stills, etc.



Immersion Type Electric Water Heater, for mounting in the Bottom of the container.

Projecting at right angles from one end of the casting is a hollow extension carrying locknuts and washers and through which runs the extension cord.

To install the heater, a 1¼ inch hole is drilled through the bottom of the container and the heater inserted from the top, so the extension through which the cord is run projects downward through the hole. Tightening the nuts and washers holds the heater rigid, and prevents leakage.

By means of a snap switch on the heater cord three different heats may be obtained: 1200 watts, 600 watts, 300 watts. If more than 1200 watts are desired, two or more heaters may be used in the same container. Standard heaters are made for 110, 120 and 220 volts, and may be used on D. C. or A. C. circuits. The heaters are manufactured by The Cutler-Hammer Mfg. Co., of Milwaukee and New York.

CUTTING OIL FILTRATION AND STERILIZATION.

To the man who is not vitally concerned, the matter of machine tool lubrication may not appear of much importance. On the contrary, it is of proven importance, otherwise there would not be the demand for such a large number of different cutting oil liquids and compounds.

It was not so long ago when the ability to increase production by liquids applied to cutting tools was recognized and the initial stels taken along that line. Water was first liquid tried, used as a stream feed, or provision made so it would be allowed to trickle upon the tool and work. A little experience in this way proved that a mixture of soda and water was more satisfactory all around, as the tendency to rust nad corrode was largely overcome.

The evolution of machine shop practice, requiring high speed tools, carried with it efforts of extreme accuracy in machining and the element of increased production. With the speeding up of tools it was readily recognized that in order to keep down operating costs and produce a product of the highest quality, it would be necessary to use a cutting fluid which had not only the cooling properties necessary to absorb excess heat, but lubricating qualities as well, to increase accuracy, decrease the power consumed, and at the same time speed up production.

With the production of a cutting oil which would serve the double purpose came the increased cost and this item must, of necessity, be kept at the lowest possible figure, otherwise the product could not be marketed. It was, therefore, apparent that an equipment which would filter and sterilize the liquid would eleminate the necessity of throwing the used oil away. This method would reduce cutting oil expense and still promote high speed operation.

To meet this need, S. F. Bowser & Company, Inc., Filtration Engineers, Fort Wayne, Indiana, designed a filtering and sterilizing system which will soon be placed on the market. The illustraiton gives a good idea of its appearance and construction. These embody the tried and true principles of screening, precipitation, filtration and sterilization, all combined in a commercial and practical manner. This class of filtration is not a venture or experiment; the Bowser Company have had systems, essentially the same, in service for several years, which are giving the very best results.

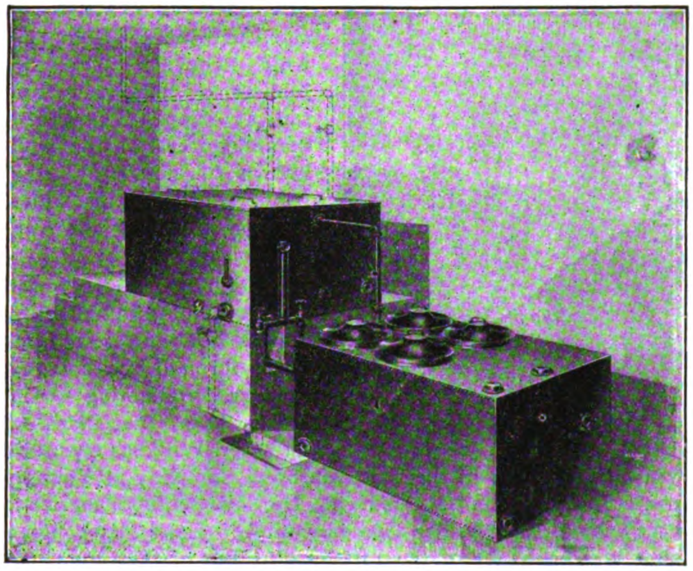
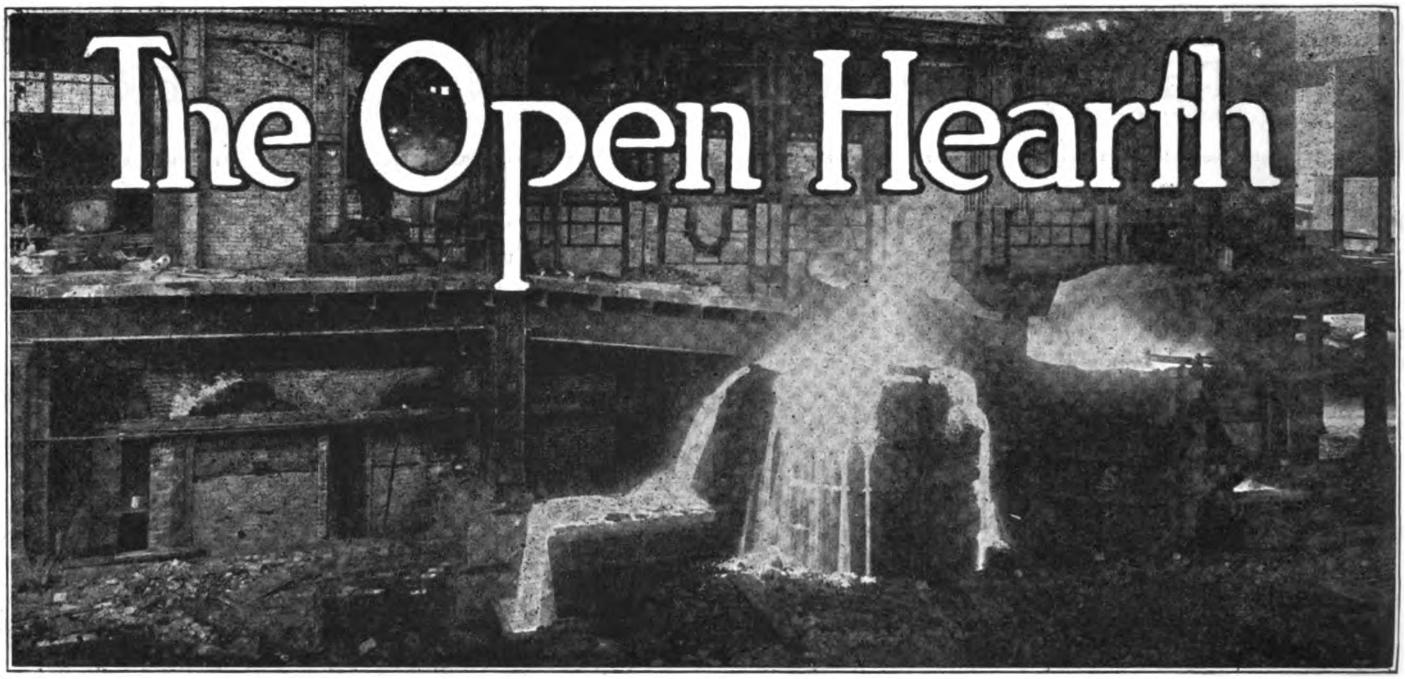


Fig. 1.

An installation of this kind will increase the life of the cutting tools, decrease power consumption, permit higher operating speed, increase accuracy, give better lubrication and save throwing away oil which has been used. By this conservation a better grade of oil can be used—one which will not foam, rust or corrode the work or tools. While the filtering process, which is automatic, is under way, the oil is also sterilized, thus eliminating obnoxious odors and preventing infection, thereby preserving the health of the employes.



The Open Hearth

BLAST FURNACE PERSONALS.

W. Woodward Williams, vice president of the Reading Iron Company, Reading, Pa., has resigned from that concern, and on September 1st, became assistant to the President of the Pittsburgh Gage & Supply Company, Pittsburgh, Pa. It is understood that Mr. Williams has acquired a substantial stock interest in the Pittsburgh Gage & Supply Company, which concern are large jobbers of mill, mine and railway supplies, and also manufacturers of the well-known "Gainaday" electric washing machines, ironing machines and vacuum cleaners.

W. Woodward Williams

Mr. Williams is very well known among manufacturers of iron and steel products through the country. After graduating from Harvard in the Class of 1905, Mr. Williams spent six years in the mills of the Carnegie Steel Company at Youngstown, Duquesne and Pittsburgh. His first selling experience was with Bourna-Fuller Company at Cleveland; later being appointed manager of the Pittsburgh office of that company. In January 1914, he became general sales manager of the A. M. Byers Company, Pittsburgh; later being appointed general manager of the same company. He left the Byers company to become general manager of the Reading Iron Company and later was elected vice president of the same concern in charge of sales and operations.

Mr. Williams has a wide acquaintance not only among manufacturers but users of iron, steel and tabular products throughout the country, and on securing an interest in the Pittsburgh Gage & Supply Company, he will give to that concern the benefit of his very wide and successful business experience.

Barton R. Shover, a member of the Blast Furnace & Steel Plant advisory board has been retained as engineer in connection with large improvements to be made by the Collins Company at Collinsville, Conn.

V V

Harry A. Deuel, assistant to the manager of the Minnequa Steel Works, and for nineteen years in the employ of the company at Pueblo, resigned August 1 to become chief engineer of the Atlantic Steel Company at Atlanta, Georgia. Mr. Deuel first entered the employ of the Colorado Fuel & Iron Company as a draftsman. Later he was master mechanic and chief engineer of construction. He was then advanced to the position of superintendent of shops and afterwards was placed in charge of the open hearth department. From this position, he was transferred to that of assistant to the manager.

V V

Harry O'Brien, formerly superintendent of the hot strip mill at Trumbull Steel has been appointed general superintendent of the plant. Mr. O'Brien was designer and patentee of the present strip mill.

V V

Coincident with the departure of Morris Metcalf for England, to be absent two or three months, comes the announcement of his appointment as president and a director of International Steel Corporation, 51 Chambers Street, New York, a subsidiary of the American International Corporation.

V V

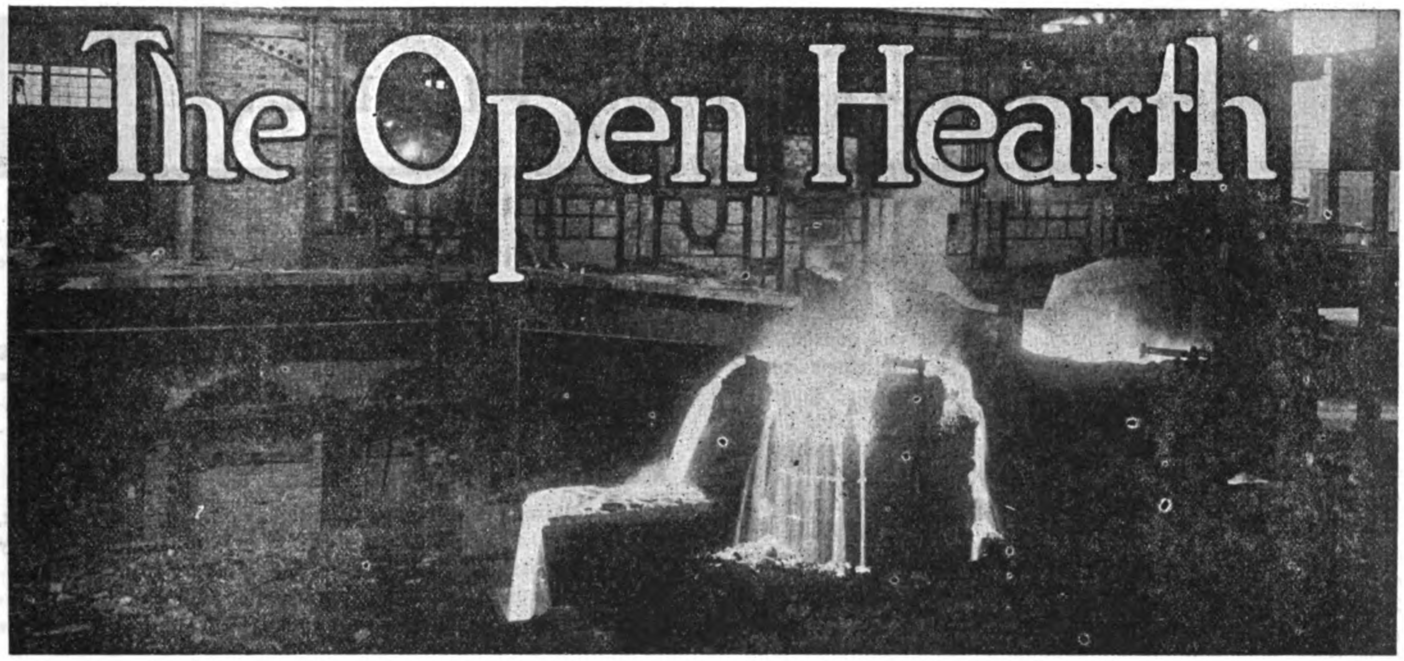
Ross Cost has resigned his position with the efficiency department at the Southside Works of Jones & Laughlin Steel Company to become assistant manager of the railway department of the Fuller Steel & Iron Company, Park Building, Pittsburgh, Pa. Mr. Cost is a graduate of Carnegie Institute of Technology.

V V

O. A. Woerner has accepted a position with the Scullin Steel Company of St. Louis, Mo., as office manager. Mr. Woerner had been with the sales department of the Cambria Steel Company for the past 17 years.

V V

Dr. George B. Waterhouse, a member of the Editorial



The Open Hearth

Advisory Board of The Blast Furnace & Steel Plant magazine has been appointed inspecting and metallurgical engineer of the Lackawanna Steel Company, Buffalo, N. Y.

√ √

Fred Hubbard, formerly chief construction engineer of the Ohio works of the Carnegie Steel Co., Youngstown, Ohio, and who was attached to the ordnance department of the United States Steel Corporation during its existence, serving as chief construction engineer at the Neville Island ordnance plant, has become chief construction engineer of the Carnegie Land Company, Frick Annex Building, Pittsburgh, Pa.

√ √

H. P. Bestwick was elected treasurer of the LaBelle Iron Works at a recent meeting of the Board of Directors.

√ √

J. S. Fraser hsa accepted the position as resident manager for the new Trumbull Cliffs Co., Warren, O. Mr. Fraser recently resigned from the Pittsburgh Steel Company.

√ √

R. C. Kirk, who recently resigned as president of LaBelle Iron Works, also has resigned as president of that company and from the Wheeling Steel Corporation, of which he was director and a member of the executive board. Mr. Kirk expects to take a much needed rest after 26 years of continuous service, and has made no plans for the immediate future.

√ √

George M. Wright, formerly president and general manager of the Wright Wire Co., now a part of the Wickwire Spencer Steel Corporation, is to become a member of the new McClure, Greene Engineering Co., Worcester, Mass.

√ √

Alexander Glass, chairman of the board of Wheeling Steel Corporation, Wheeling, W. Va., recently organized as a merger of the LaBelle Iron Works, Whitaker-Glessner Co., and Wheeling Steel & Iron Co., comes from an essentially iron and steel family. His father, Andrew Glass, was one of the original founders of the LaBelle Iron Works at Wheeling in 1852. Mr. Glass first engaged in the iron and steel industry in 1873, and between that period and 1890 was employed by several companies in that field. In 1890 with others, he organized the Wheeling Corrugating Co. and served as secretary. In 1908 he became president of the Portsmouth Steel Company, Portsmouth, Ohio, having previously held the office of vice president. His election to the presidency of the Whitaker-Glessnes Co. followed in 1910.

√ √

Veryl Preston has resigned as president of the Cromwell Steel Co., Cleveland, with works at Lorain, Ohio. Mr. Preston was elected president of the Cromwell Steel Company a year ago after retiring from the presidency of the Eastern Steel Co., Pottsville, Pa. C. A. Orr, vice president, is directing the company's affairs until a new president is elected.

√ √

N. J. Vadarvaux now is assistant superintendent of the American Steel Co, Ellwood City, Pa. He recently resigned as assistant manager of the order and wholesale department of the American Steel & Wire Co., Cleveland.

√ √

F. C. Laughran, formerly with the Jones & Laughlin Steel Company, Pittsburgh, Pa., has accepted a position as superintendent with the Electric Alloy Steel Company at Charleroi, Pa.

√ √

J. L. Landt has been appointed superintendent of the Buffalo plant of the Semet-Solvay Co., manufacturers of coke and by-products.

√ √

The Collins Company, Collinsville, Conn., have started extensive improvements to their plant, which will include a new bar mill and steel making plant. The products of the company are axles, etc., and they have a large export trade principally in South America. Barton R. Shover, consulting engineer of Pittsburgh has been retained as engineer in charge of improvements.

√ √

Walter F. Schulz, who for the past year has been production manager and chief engineer of the Sharon Pressed Steel Hoop Co., Wheatland, Pa., has resigned to become connected with the Truscon Steel Co., Youngstown, Ohio. Mr. Schulz is succeeded by O. C. Steinert, formerly assistant engineer. For four years prior to going to the Sharon company, he was with the Savage Arms Corp.

NEWS OF THE PLANTS

The Ewald Iron Company, Louisville, Ky., manufacturer of bar iron and general iron products, is planning for the erection of a large addition to its plant. A site in this section, comprising about 20 acres of land, has been purchased and preliminary plans for the new works are under way. The plant will consist of a number of fireproof buildings, with iron fences, eight new rolling mills, bloom department and other structures. It is proposed to develop a capacity of about 50,000 tons of refined charcoal bloom hammered iron per annual, specializing in material suitable for locomotive construction. The present plant consists of a total of four mills, with annual output approximately 12,000 tons; this plant is giving employment to about 400 men, and it is planning to utilize a working force of about 1,000 employes at the new works. The entire plant is estimated to cost in excess of $2,500,000, including equipment. Details of plant and equipment are now being developed. R. Baylor Hickman is president and H. E. Pierce, general manager.

The Baltimore Malleable Iron & Steel Company, Charles and Wells Streets, Baltimore, Md., has preliminary plans under way for the erection of an addition to its plant for increased output; it is planned to double the present capacity. The work will include the installation of new blast furnace equipment and considerable other apparatus, and it is estimated to cost about $100,000.

The Iron Mountain Furnace Company, Iron Mountain, Mich., recently formed with a capital of $1,000,000, will defer the erection of its proposed new local plant until early in the coming year. In the meantime details of the works will be perfected, including the proposed equipment installation. The company will specialize in the production of high grade pig iron, as well as important by-products. M. E. Richards is manager.

The Kittanning Iron & Steel Company, Kittanning, Pa., is completing plans for the erection of an addition to its plant for increased capacity. The new structure will be one-story and is estimated to cost about $100,000, including equipment. The Arthur G. McKee Company, 2422 Euclid Avenue, Cleveland, Ohio, is engineer and architect for the work.

The Hudson City Steel Corporation, 2302 Woolworth Building, New York, recently organized with a capital of $500,000 to manufacture iron and steel products, has acquired property totaling about 12 acres of land at Hudson, N. Y., for its proposed new plant. The initial installation will consist of three tandem mills, 8, 10 and 12-inch, respectively, and several single units. A double gas producing furnace will be installed, and considerable auxiliary operating equipment. It is proposed to develop an output of about 100 tons of cold-rolled strip steel per day, and at a later date this capacity will be considerably increased. Plans are being arranged to have the new plant ready for service early in the coming year.

The Iron City Pipe & Foundry Company, Birmingham, Ala., is planning for the erection of a number of additions to its plant for increased capacity. The extensions will be used primarily for the production of standard and extra heavy soil pipe, and it is proposed to double the present output in this line. The new additions with equipment are estimated to cost about $200,000.

The Laclede Steel Company, St. Louis, Mo., is planning for the early operation of its new mill at Madison, Ill., now nearing completion. The plant will be used for the manufacture of cold rolled steel. It will be operated in conjunction with the other works of the company.

The National Malleable Castings Company, Platt Street, Cleveland, Ohio, is planning for the erection of a two-story addition to its plant at Woodhill Street and Quincey Avenue. The structure will be of brick and steel and with equipment is estimated to cost about $100,000. Henry F. Pope is president.

The Marine Iron Works Co., Berkley, Va., is completing plans for the construction of a two-story plant addition to cost about $75,000. R. O. Colonna is president.

The Huron Steel Company, Huron, Ohio, now building a local plant, has acquired a substantial interest in the Ohio Steel Products Company, Youngstown, Ohio. It is said at a later date the two companies may be merged, although they will operate as separate concerns at the present time. The Ohio Steel Company has inauguarted operations at its plant at Mineral Ridge (Trumbull County), Ohio, and will specialize in the manufacture of steel tubing, conduit pipe and other high grade products produced from strip steel. The company has an operating capital of $500,000. The Mineral Ridge plant will be run at capacity, aggregating about 20,000 tons per year.

The Sellers Mfg. Company, McCormick Building, Chicago, Ill., manufacturer of spilce bars, and other iron and steel products, is planning for the erection of an addition to its plant on Pensecola Avenue. It will be one-story, 90x150 feet, and is estimated to cost about $85,000.

The Steel Fabricating Company, Michigan City, Ind., has completed plans for the erection of a new local plant, to be one-story, 250x500 feet. Bids for construction have been taken. The new plant with equipment is estimated to cost about $400,000.

The American Iron & Steel Corporation, Michigan City, Ind., is having plans prepared for the construction of its proposed new local plant to cost in excess of $5,000,000. The initial unit will comprise a number of brick and steel buildings, to include six open-hearth furnaces, twelve sheet mills and other mills. Production will be devoted to plates, rods, bars, slabs and other products, and it is planned to develop an output of about 250 tons per day. L. L. Slick, Engineers' Building, Cleveland, Ohio, will be in charge of the work.

The Reading Steel Casting Co., Reading, Pa., has awarded a contract to the Stone & Webster Engineering Corporation, 120 Broadway, New York, for the erection of a one-story addition to its plant to cost about $200,000.

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Some Pointers on By-Product Coke Oven Operations

CONFERENCE ON BY-PRODUCT COKING IN ENGLAND.

Recently a conference on by-product coking was held in the Chemical Lecture Theater, Armstrong College. Prof. P. Phillips Bedson in the chair.

The chairman said that it was impossible to over-exaggerate the importance of the complete utilization of coal—a subject which, during the past few years, had been brought home by the increased cost of coal, but it was a matter for regret that it had taken us so long to appreciate and make headway in the practice of coking coal, especially as regards the recovery of by-products. Of the factors which had contributed to the backward condition of the British by-product coking industry the first was that in this country, and particularly in Durham, such a good supply of excellent coking coal was available. The second factor had been that in making iron it had been found that a slightly larger amount of retort oven coke was needed than of beehive coke, and that undoubted experimental fact, supported by the dictum of Sir Lothian Bell, had deterred many from embarking on the recovery of by-products when coking coal.

UTILIZATION OF COKE OVEN GAS.

The utilization of coke oven gas has become of considerable importance, due to the world-wide shortage of fuel, the increased production demanded of industrial plants, the higher economy to be derived from the intelligent application of this form of fuel, and to the increasing use of by-product coke and the consequent production of coke oven gas.

The principal industrial applications of by-product coke oven gas are to open hearth furnaces, soaking pits, heating furnaces, crucibles, boilers, gas engines, foundries, etc., where its success is attributable to the high temperatures obtainable, to the lower operating costs as compared with coal, crude oil and tar, and to the increased furnace or boiler efficiency.

Some years ago there was considerable antagonism towards the use of coke oven gas in open hearth furnaces. This feeling was caused by the original mistakes and failures due to the haphazard and unscientific study made prior to the first installations. Today conditions are reversed. At first, when used in furnaces designed for natural or producer gas, difficulties were encountered by the fluxing of furnace tops, because of the greater buoyancy of coke oven gas (specific gravity .33 to .42) as compared with natural gas (specific gravity .55) or producer gas (specific gravity 1.0).

By changing the design of the furnace tops to meet the altered conditions and by the development of entirely new types of burners, this roof trouble has been eliminated. The most successful type of burner seems to be one using a combination of gas and tar. The tar is vaporized as it enters the furnace just above the gas burner, protecting the top from the direct impact of the gas flame and also giving greater luminosity to the flame, a decidedly desirable result in open hearth operation.

Today all of the major difficulties of the past have been overcome, and coke oven gas is established as one of the foremost fuels in some of the largest and most skillfully run plants, among which may be mentioned the following:

Illinois Steel Company, Gary, Ind.; Bethlehem Steel Company, South Bethlehem, Pa.; United Furnace Company, Canton, Ohio; Carnegie Steel Company, Clairton, Pa.; Youngstown Sheet & Tube Company, Youngstown, Ohio; LaBelle Iron Works, Steubenville, Ohio; Colorado Fuel & Iron Company, Pueblo, Colo.; Cambria Steel Company, Johnstown, Pa.; Gulf States Steel Company, Gadsden, Ala.; Dominion Iron & Steel Co., Sydney, N. S.

Coke oven gas has often been a desirable substitute for natural gas and carburetted water gas as a domestic fuel. The diminishing supply of natural gas in many fields has directed the attention of gas companies to coke oven gas as a source of supply and today several by-product coke plants are under construction which will deliver coke oven gas to supplement the production of natural gas.

Many cities of the United States now use coke oven gas either wholly or mixed with water gas. The present high cost of materials has made water gas very expensive to manufacture, for the gas must stand all the increased costs, there being no by-products to absorb a part of the costs. The manufacture of coke oven gas carries with it the production of coke, tar and ammonia. When the prices of coal increase, the prices of these products increase and the gas alone does not have the full burden to bear.

Plants of Koppers ovens are now supplying coke oven gas to the following cities:

St. Louis, Mo.; Newark, N. J.; Baltimore, Md.; Jersey City, N. J.; St. Paul, Minn.; Toledo, Ohio; Terre Haute, Ind.; Providence, R. I.

TAR DISTILLING PLANTS.

By distillation, the coal tar is separated into a number of fractions graded arbitrarily by temperatures in the tar still. These fractions are usually called light oil, carbolic oil, middle oil, creosote oil, heavy oil, anthracene oil, soft pitch and hard pitch. This group of products covers the usual range of results obtained under the first distillation of crude tar.

The Koppers Company has built plants for tar distillation at the following places:

American Tar Products, St. Louis, Mo.; American Tar Products Company, Youngstown, Ohio; American Tar Products Company, Woodward, Ala.; Canadian Tar Products Company, Montreal, Canada.

These plants are modern in every respect and combine the latest developments of both European and American practice. The stills are designed to handle fifty tons of tar per charge and the distillation time is from seven to eight hours. Stills to be fired with coal as fuel are equipped with automatic stokers having a wide range of firing.

In the condenser house many economies are introduced by means of heat exchangers and complete control of all apparatus is had by means of recording and indicating devices.

These plants are designed to be operated with a minimum of labor, the greater part unskilled, materially reducing operating costs.

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TRADE NOTES

The Fawcus Machine Company, to facilitate the handling of its enlarged business, has consolidated all departments in its new office building at 2818 Smallman Street, adjoining the Pittsburgh works. A down town office for meetings by appointment will be maintained in Suite 1501 Peoples Savings Bank Building where its allied company, the Schaffer Engineering & Equipment Company is located.

The Celite Products Company announce that they are now represented in the Buffalo district by The Empire Company, 344 Ellicott Square, Buffalo, N. Y.

The Knoxville Iron & Steel Co., Knoxville, Tenn., is preparing to use powdered coal for puddling, busheling and reheating furnaces as well as for boilers to replace their present hand fired method. Contract has been closed with the Quigley Furnace Specialties Co., 26 Courtlandt St., New York City for a complete system including coal milling plant and equipment for distributing and burning the pulverized fuel by the Quigley Compressed Air System. Work on this installation is to be started immediately.

The Blaw-Knox Company will have an exhibit at the American Foundrymen's Association Exhibition to be held October 4th to 8th inclusive, at the Ohio State Fair Grounds, Columbus, Ohio, which will consist of clam shell buckets, waer cooled furnace appliances and prudential steel buildings. Their booth will be No. 308.

S. W. Fries has been appointed district sales manager for Kansas City territory of Economy Fuse & Manufacturing Company with offices at 1205 Commerce Bldg., Kansas City, Missouri.

Mr. Fries succeeds R. P. Crawley who has resigned the position to take over the active management of the Crawley Electric Company of Peoria, Illinois.

Mr. Fries takes his new position with a long and thorough experience and wide acquaintance with the electrical field. He has been with Economy Fuse & Manufacturing Company for a number of years, his service with the house being interrupted only by the time he devoted to patriotic duty in France.

"Freyn, Brassert & Company, Engineers and Constructors, Chicago, Ill., have been awarded the contract to install a Dorr Thickener in connection with the gas washing plant of the Shenango Furnace Company at Sharpsville. This installation will clarify the waste water from the existing gas washers and recover the flue dust removed from the gas for utilization in the blast furnaces."

Mr. Julius Janes, formerly President of the Standard Steel Castings Company of Cleveland has recently concluded an arrangement with The Farrell-Cheek Steel Co. of Sandusky, Ohio, by which he will be the sales representative of this organization in Cleveland and Cuyahoga County.

Of more than passing interest to the trade is the announcement that Mr. A. B. Way, until recently secretary and general manager of The Bridgeport Chain Company, has become affiliated with The Chain Products Company of Cleveland, Ohio, in the capacity of District Sales Manager for New England, with headquarters at the company's New York office, 150-152 Chambers St.

TRADE PUBLICATIONS

C-H water heaters of both immersion and conduction types are described and illustrated in a new 4-page, 8½x11 leaflet entitled, "Electric Heating of Water," and published by The Cutler-Hammer Mfg. Co., of Milwaukee and New York. This leaflet, which is designated as Publication 865, also compares electric heat with other methods of heating water, and gives formulas and tables whereby the size of heater desired under any particular conditions can be readily determined.

The leaflet describes three different types of immersion heaters, namely, bottom outlet, pipe outlet, and circulation. The former is mounted in the bottom of the water container; the pipe outlet heater is inserted in the pipe loop of a hot water tank or other container.

Standard Iron-Steel-Metal Directory published by the Atlas Publishing Company, Inc., New York City, is now ready. It is the most complete directory ever published.

Bulletin No. 1 of the Reading Iron Company has received a great deal of favorable comment from the trade due to it being one of the most instructive booklets ever published by a pipe manufacturer. Among the interesting articles included in it are "Origin and Development of the Wrought Iron Industry," "The Puddling Process," "The Manufacture of Skelp," etc.

Data Book for Engineers.

The Locomotive Superheater Company has issued a most unique and interesting "Data Book for Engineers," which has received considerable comment.

"Case Carbonizing."

"Case Carbonizing," the Driver-Harris Co. of Harrison, N. J., has published within the last month a book on Case Carbonizing.

The rapid growth of the steel industry in the past thirty years has been reflected along all lines of metallurgical work.

The progress has been stimulated at every step by the scientific investigation of the problems involved. This scientific control has resulted in introducing economies in the operation of the older processes and in devising new methods for the attainment of new ends.

It is not surprising, then, to find that, in the field of "Case Carbonizing" or "Case Hardening," a large amount of information has been accumulated which is of value to the heat treater. It is no longer necessary to carry out the process of "Case Hardening" along purely empirical lines. The chemical reactions which are involved in the various methods used for "Case Hardening" are now well understood. The quality of the steel which should be used, the nature of the carbonizing compound, the temperature and time of the operation and the nature of the container have all been subject to investigation.

While this information is to be found in the scientific files, it frequently happens that it is not available to the heat treaters on whom devolves the practical application of heat treating processes involved.

This booklet, then, aims to lay before the heat treater, in language which can be readily understood, the information which has been rendered available by the more recent scientific investigations.

"Hytempite" is the name of a 16-page bulletin just published by the Quigley Furnace Specialties Co., 26 Cortland Street, N. Y. In it they discuss the correct method of patching and laying fire brick and the use of their hytempite cement.

Another Account of German Treachery During the War.

A few months before the armistice was signed, a Hamburg liner owned by a German agency, was interned at an American port and taken over by the United States Government for war service.

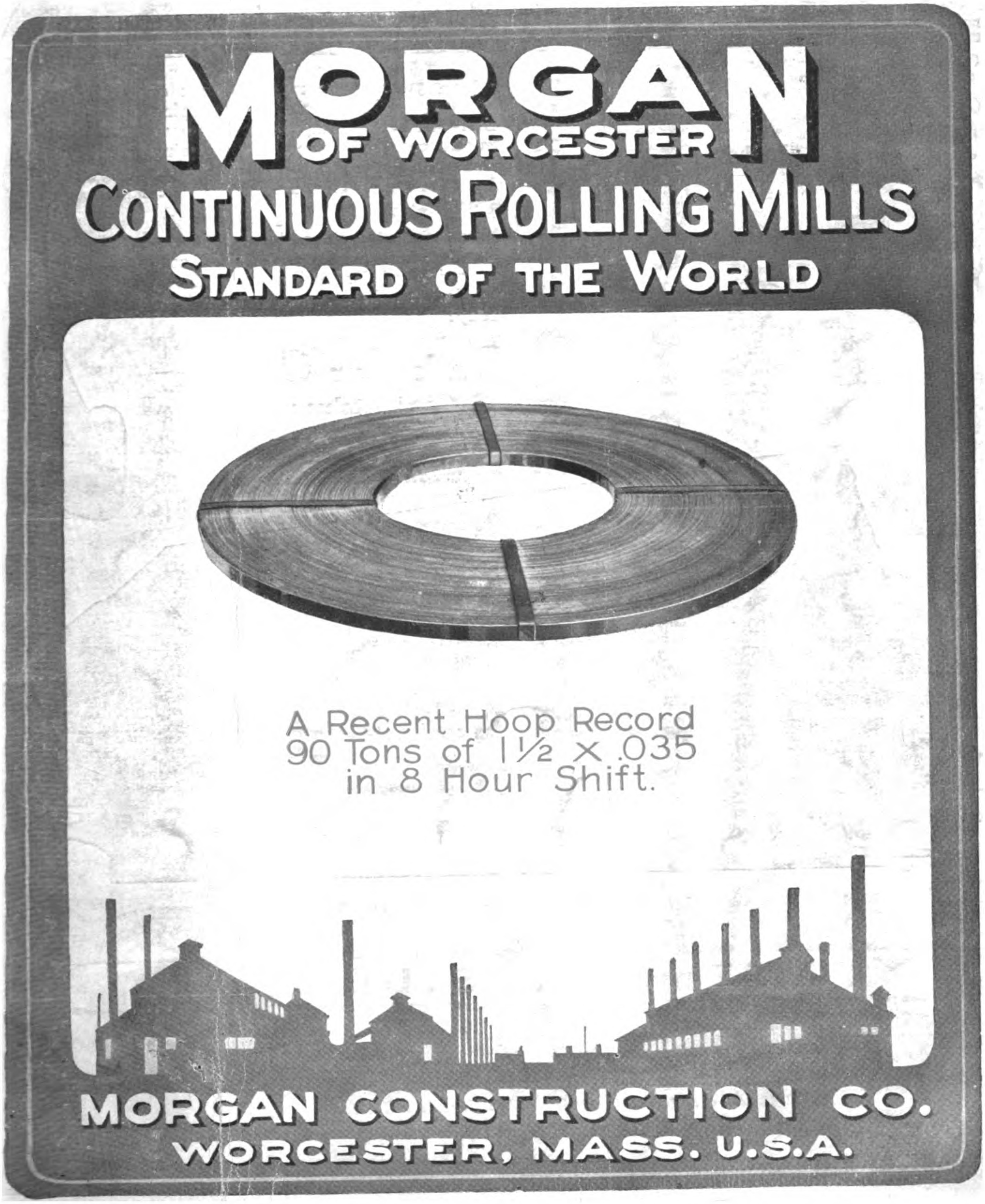
The lack of reluctance on the part of the ship's officers when leaving the ship at once aroused suspicion and served to intensify the inspection given interned ships. Preliminary investigation failed to justify our officers' belief that the vital parts of the ship had been tampered with; however, after days and weeks of examination, during which time not an inch of the ship was overlooked, it was found that every ninth or tenth rivet on the ship's boiler had been removed and wooden pegs substituted. These wooden pegs were the same shape as the steel rivets and had been painted to match. Only by tapping and noting the unmetallic sound were they discovered. Experts said at the time that the boilers might have held for several hours before bursting. No doubt the Germans planned to allow the ship to get well out to sea before their labor would bear fruit.

However that may be, the point is forcibly brought out that ship rivets, whether in the boiler or hull plates, are the most vital parts of its construction.

Member of the Audit Bureau of Circulations.

The Blast Furnace and Steel Plant

Pittsburgh, October, 1920.



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